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Innovation in StatoilHydro

– a case study of knowledge development in a large Norwegian company

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Abstract

The aim of this thesis is to provide insights as to how innovation may be influenced by knowledge and learning. This is done through assessing what drivers of innovation StatoilHydro is operating under, and how the company develop and use knowledge under these conditions. The oil and gas industry is subject to specific conditions related to market and regulations, which calls for the development of particular competencies related to knowledge. Development and use of knowledge is crucial to meet innovation-challenges, and does not follow some automatic pattern. In order to increase the understanding of how innovation comes about in StatoilHydro, I have applied an analytical framework which situates StatoilHydro in its larger sectoral and technological context, and considers different modes of learning and innovation. In addition to this I have also applied literature on organizational practices related to learning and knowledge. The main emphasis of this thesis is on different practices which are seen to enhance the development of knowledge and consequently, innovation.

Keywords: innovation, knowledge development, organizational practices, opportunity conditions, the Norwegian oil and gas industry

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Oslo, 21.05.2009

Mari Kristine Kallåk

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1.0 Introduction

The objective of this thesis is to increase the understanding of how knowledge and learning takes place in large companies, in the context of innovation activity. Organizations are faced with changing environments in which opportunities to innovate are affected by this change as well as the companies own efforts towards handling change and learn from it. Knowledge development and learning is important for innovation, but there are many approaches to this depending on size and objective of a company, as well as the initial internal composition of knowledge and expertise. One way of making processes of knowledge development explicit is to view them as two complementary modes of learning and innovation (Jensen et al 2007).

Processes of innovation have traditionally been viewed as relatively linear and tidy occurrences which are fuelled by basic research. Basic research has thus been valued as the critical source of innovation, and policies aimed at enhancing innovation has correspondingly emphasized the strengthening of basic research. However, analyses of empirical evidence has suggested that this is a skewed view of how innovation come about, and that the processes in reality are far more complex and dynamic than what is described in the linear view and encompass different types of knowledge that is brought about in different ways. This alternative understanding has implications for the shaping of innovation policy, as well as the learning strategies for innovating companies.

1.1 Approach

In order to provide empirical data for analysis, I have chosen to do an explorative case study. The empirical field is two research centres, within StatoilHydro.

1.1.1 StatoilHydro

StatoilHydro is a Norwegian energy company with approximately 29 500 employees in 40 countries. It operates 39 active oil- and gas fields, and produces more than 1.7 million barrels oil equivalent every day. The company is world-leading in carbon capture and storage (CCS), and the largest operator in waters more than 100 metres deep. There are six business areas; Exploration and Production Norway, International Exploration and Production, Natural Gas, Manufacturing and Marketing, Projects, and Technology and New Energy. The research centres are located under the Technology and New Energy area (statoilhydro.com). Both centres participating in this study are relatively autonomous, in the sense that they may choose their own strategies of research and innovation within company policies. In addition to this they participate in collaboration with the other centres, and with other actors internal and external to the StatoilHydro system. When working on projects, they apply a matrix organization, meaning that people are assigned from different departments and put together to solve tasks.

Statoil and Norsk Hydro Oil and Gas merged and became StatoilHydro on the 1st of October 2007. There are now three distinct research centres in the StatoilHydro system, and several other research facilities. Prior to the merger, two of the research centres were part of Hydro, and the third was part of Statoil. The two selected research centres are located in Porsgrunn (RCP), and Trondheim (RCT), originally ex-Hydro and ex-Statoil respectively (statoilhydro.com). Given the short amount of time since the merger (at the time of data collection approximately 1 year), it can not be expected that the company is integrated on all levels and areas. However, selecting centres from both ex-companies will most likely give a broader and more balanced empirical base for analysis. In the analysis, no emphasis will be made on the origin of the centres. They will be treated as equal representatives of innovation activity in StatoilHydro.

I have applied a case-study approach, and conducted interviews, documentary analysis and observation. Of the interviews, five are in-depth interviews with people of different positions in the research-organisation in StatoilHydro. The other five are more informal conversations with innovators, about specific cases of innovation-projects. In addition to this, I have observed an arena for exchange of challenges and ideas. I wanted to talk with people who have different positions and thus different experiences with innovation in StatoilHydro, in order to gain a broad understanding of the innovation activity. Further, relevant documents has been read and analysed.

1.2 Research Questions

In order to increase the understanding of how development of knowledge and learning takes place in large companies in the context of innovation activity, the following research questions are asked:

> *What drivers of innovation is StatoilHydro operating under, and what kind of needs for knowledge development follows of these?*

And furthermore:

> *How is the firm organizing its knowledge development and use under these conditions?*

1.3 Main sources of influence

Research institutes in Norway and abroad have contributed heavily to research on innovation activity in business and industry. Growth, Innovation and Policy (GIPOL) is a collaboration project between the Norwegian research institute NIFU STEP, Norwegian School of Management, University of Agder, and the Swedish University of Lund. It is funded by the Norwegian Research Council, and lasts from 2007-2010. The aim of the project is to "(…) analyze modes of innovation and knowledge networks in order to develop an analytical framework adapted to the increasing globalization of the economy. Within this framework, innovation processes in firms and in different regional contexts will be analyzed" (GIPOL 2009). The project also aims to discuss how the new understanding might have implications for the development of national innovation policy. Especially Work Package 1 of the project considers innovation processes in companies. The project Nordic Innovation Indicators (NIND), lasting from 2006 -2008 has also been important in developing an understanding of innovation in the Nordic countries.

In addition to this, analyses, reports and articles have been issued by other institutional actors. Among these we find the Organisation for Economic Co-operation and Development (OECD), and the Norwegian Research Council with different reports (www.oecd.com, www.nfr.no). The perspectives in these works are predominantly systemic, sectorial or regional, and make extensive use of quantitative data.

The Danish DISKO survey (1996-1999) aimed at achieving a better understanding of relations between Danish economy, competence-building and innovation (http://www.business.auc.dk/disko). I refer to results from the DISKO project in this paper. Another relevant research project is the Canadian survey named Managing Innovation in the New Economy (MINE), which comes out of the Ecolé Polytechnique Montreal (http://www.minesurvey.polymtl.ca/). This project takes a closer look at each firm participating in the survey; the data being applied is standardised and quantitative. I make use of some topics and perspectives from the MINE-survey in this paper.

There has been done extensive research on organisational knowledge and innovation. The Danish DISKO survey has been used as empirical basis in an analysis conducted by Jensen et al. (2007). An article stemming from this work considers different types of knowledge in relation to innovative performance. It also puts emphasis on the view that innovation surveys and approaches to innovative processes in many cases seem to be biased, favoring science and technology as important knowledge bases and neglecting forms of knowledge stemming from experience, skill and know-how. The Jensen et al. (2007) article provides part of the theoretical framework for this paper, and will be dealt with on a more detailed level later on in this paper. I will also make use of theoretical perspectives concerning organisational design and innovation, and high performance work systems. Also of interest in this paper is the development of the oil- and gas industry in Norway, which will I will briefly account for in section three about the history and contemporary context of innovation and the oil- and gas industry.

I have chosen to write about knowledge development in relation to innovative activity within one major company in the oil- and gas industry. This means that I am examining one specific case of innovative activity using qualitative empirical data, in contrast to the aforementioned projects in which the scope is systemic, sectoral, or regional and the empirical data are predominantly quantitative. This is not a paper about indicators of innovation. Neither is it about sectoral or regional characteristics of innovative activity, or on the importance of innovation for economic growth. These topics are however relevant to the study in the sense that they to some extent describe the broader environment in which a company has to operate.

I will not consider innovation systems in relation to StatoilHydro, as the scope of the study is relatively limited. Innovation systems on local, regional, national and global levels are however of current interest in national and international research. Knowledge development is relevant on all these levels, and its consequences may be read economically and politically. There are a lot of research on innovative activity and knowledge on systemic, sectoral and regional levels, but not so much on company level in terms of knowledge and innovative performance. One big question is how improved innovative performance may affect society economically. This paper does however not consider questions related to economic growth in national economies, or on any other level.

Also relevant to the topic of knowledge development and innovation systems is the relationship between the educational system, the R&D sector, and business. Knowledge is obviously a major factor in the relationship. Put very simply, the educational system provides competence to R&D and business, R&D provides basic and applied research, and business provides economic incentives for further education and R&D. This paper does not elaborate on issues regarding this relationship; but it will consider the linkages between StatoilHydro's innovative activity and internal and external actors, in so far they are relevant to the internal organisation of development and use of knowledge.

The difference between the research presented in this paper, and research done within the context of the aforementioned projects and institutions, is thus; that my study is done on company level, within one firm, and makes use of qualitative empirical data. Further, I attempt to describe factors which influence and condition development and use of knowledge on company level. To the extent such research has been done, it has predominantly made use of surveys. I am using qualitative interviews and observation to achieve a thorough understanding of a limited empirical field.

1.4 Outline of the thesis

This thesis aims to answer the research questions stated above. Chapter one provides a general overview of topic, methods and context. The second chapter provides an account of innovation as concept and some history on innovation, an account of the start and development of the Norwegian oil and gas industry, and a brief walkthrough of the White Paper o Innovation 2008-2009.

Chapter Three presents the analytical concepts of environment conditions and structural archetypes, and modes of learning and innovation.

Chapter four provides an account of the research design and methods, and the validity and reliability of this study.

Chapters five and six present the empirical findings and discuss these in light of the analytical framework.

Chapter seven summarizes main findings and propositions based on the analysis in chapters five and six, and some views on what implications this might have for StatoilHydro, future innovation policy, and further research.

2.0 Background

In this section I will account for innovation as concept, the general historical setting of innovation, and some views on innovation processes. The organization of R&D and the role of the Researcher have changed quite a lot through the course of history. In addition to this, I will provide an overview of the history of the oil- and gas industry in Norway. I believe that to be better equipped in understanding the challenges of innovation in the industry today, it is important to have some knowledge of the historical context of innovation as well as the industry-specific development. Norwegian oil- and gas industry has been subject to various regulations and control mechanisms. It has also been characterized by a high degree of state ownership, and attempts by the government to organize and provide incentives for certain ways of doing R&D. This historical context might give some useful insights as to how the situation of today has come about. The last section provides an account of the White Paper on Innovation 2008-2009, and how this may be seen in relation to StatoilHydro's activities.

2.1 Innovation

The history of innovation is in many ways as long as the history of Man. Humans has always tried to find ways of doing things easier, more efficient, and producing more at a better quality. The following provides a definition of innovation. This provides insights as to how innovation may be understood in the context of StatoilHydro

2.1.1 Innovation as concept

Defining innovation as a concept is not easily done. It definitively relates to *something* that is new, but what is this something, and how is it new? Joseph Schumpeter (1883-1950) described innovation as *creative destruction*, implying that an innovation may destroy the old, in a way the benefits the society. Joel Mokyr coined the term *history's free lunches*, indicating that innovations may make it possible to harvest profits which have not been available with the old technology. Innovation as *something new* may be contextually divided; *new to the world* are big innovations which achieve a broad diffusion; *new to society* are innovations which a society has not known of earlier, but it may exist in other societies; *new to the company or the local community* refers to the implementation of something that appears as new in a local context but is diffused elsewhere. *Diffusion* is thus another important concept; an innovation is not an innovation before it has been put to use. (Godø 2008)

It is important to note that *innovation* is not the same as *invention*. An invention is an idea of a new technical construction, a process, a material or service, and some documentation that this would work as intended. An innovation may be built on an invention, and is thus the actual realization of an idea. Innovations may be characterized by their potential to change their surroundings. An *incremental* innovation imposes only small changes on processes or products. *Radical* innovations may significantly change products, processes or economic sectors. Further, some innovations may change *technological systems*, bringing about new economic sectors or business types. Lastly, some innovations may change the *techno-economic paradigm*, changes which are brought about by several radical innovations which influence the organization of a society. The Industrial Revolution is an example of the latter type of innovation. (Godø 2008) However, the processes of turning ideas and knowledge into innovation have been much disputed. Innovations and the processes by which they come about are in a sense a *black box* which needs to be opened up. Examining the elements and dynamics prior to the wide diffusion of an innovation is an important practice in order to understand these processes, and thus being able to make improvements. (Latour & Wolgar 1986)

The following section will draw some general lines in Western innovation history and the perception of the Researcher, from the early beginnings in the 18th Century and onwards.

2.1.2 The History of Innovation

One popular view of the researcher, especially in old times, is the notion that he (or she)[1] is an *extraordinary individual*. Great innovations have come about because the person behind it is perceived to be a genius and possesses unusual talents, and is often thought of as a distinct entrepreneurial type. Marie Curie, Thomas Edison, James Watt, and the Norwegian Kristian Birkeland are examples of famous inventors and scientists that have been given status as extraordinary individuals. The admiration of these heroes was probably a result of the cultural and economic situation of the times, when nationalism was strong and there was a thirst for

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[1] *Extraordinary individuals* have been men *and* women; however, this view on researchers was prevailent in the late 19th century and early 20th century, when men dominated science and technology development. (Godø 2008)

national heroes who could represent excellence and ambition. Some common characteristics of the extraordinary individuals are high intelligence, creativity, dedication of time and effort to their work, often a suffering social or family life because of the time and energy spent on the research, and special social and political skills which are helpful in convincing funders. This view on the Researcher is however of limited application. It disregards that these extraordinary individuals usually draw in work from several people around them, without which they would never be able to do their work. Society's need for heroes, particularly in the 19th century, meant that some men were glorified and mythologized as almost superhuman. However, some men have contributed heavily to technological development and not been credited, while others gave only small contributions but received most of the credit for it. The important point here is that the emphasis is on people and heroes, which leaves the process of innovation in a haze. Inventions are mixed with innovations, and all the people, organizations and businesses are left out of the equation (Godø 2008:46-49). An important element in this thesis is to open up the innovation processes in order to gain insights as to how people, organizations and businesses work together and develop knowledge which is essential to innovation in StatoilHydro.

The Industrial Revolution brought with it radical changes in production and social organisation. New technology and processes made it possible to save resources, produce more efficiently, and to employ less people. The pace of technological innovation was relatively slow in the early industrialisation, but picked up the pace after some time. In Great Britain, innovation was characterized by *learning by doing*, relying on skill and knowledge of the industry. Skilled workers developed technical solutions to known problems in the industry due to extensive practical knowledge of the problems and a process of trial and error. Some people made a living out of creating patentable inventions. Science was modestly developed and concentrated on areas with little or none industrial application; for instance astronomy, magnetism, crystallography etc. Some science was picked up by industry, but this was older in nature and associated with the Scientific Revolution; examples include chlorine for bleaching. Industry and technology was most likely a source of development in science, and not the other way around. The level of formal education was generally low and did not improve substantially during the Industrial Revolution. It is believed that this is a possible reason for the shift from worker-led innovation, to managers or owners to lead innovation. This in turn probably narrowed the scope for maintaining advance (von Tunzelmann 1995:117-127). A major point in this thesis is how knowledge developed through *learning by* *doing* and knowledge stemming from formal education may work together to enhance innovation.

Though Great Britain was leading in innovation in the early industrialization period, the rest of Europe followed in the period of late 19th and early 20th century. Industrialists on the European continent had been travelling to Britain to observe the technologies and processes applied by the British, but lacked an appropriate knowledge base to accommodate technologies and processes to local conditions. However, British innovators and workmen moved to the Continent and brought knowledge of how to build and operate the machinery. These were to a varying degree successful. A reason for this may be that they were not aware of why they had been successful back home, and tried to copy the technology and processes without regard to the *tacit knowledge* needed to operate known equipment in unknown surroundings. Adjusting to local environments was the key to success. The growing complexity of machinery called for new kinds of skills. Germany and France sustained relatively different educational systems. France upheld a rather elitist educational system, whereas Germany provided a more practical curriculum in secondary school, and a tertiary education in universities with pure science or applied science. In addition, this was combined with vocational training within some large firms at the end of the 19th century. Germany was not as proficient as France and Britain in scientific theory, but nevertheless found itself at the forefront of organization of science in the early 20th century. Technical training below research level in the form of polytechnics and mechanic's institutes was set up by the government, and German engineers-to-be had relatively high exposure to large companies in German industry. In France and Germany, industrial research laboratories were set up from the 1850's, often with strong links to academia. France tended to recruit individual scientists to positions in firms, whereas Germany set up research teams and divided problems for teamwork; in effect they introduced a division of labour in R&D. In-house R&D was most likely to be set up in large firms, due to scope and scale. This permitted rapid commercialization of products (von Tunzelmann 1995:161-169). The importance of *tacit knowledge* and the combination of such with formal education and skill based knowledge is essential to the innovation processes which are analyzed in this thesis.

In the period of late 19th century to early 20th, the US borrowed or copied technologies from abroad. They had to accommodate the technology to local context, especially considering that the US has a quite different terrain and natural resources. They lead ahead in technological systems, such as power-supply, which had to be organised differently because of the vast areas and scattered urban areas. For a long time development was a result of trial and error, but around the turn of the century, more formal R&D begun to emerge. Metallurgy, food processing and construction required better information, and laboratories were involved in relative routine tasks like testing and grading materials, assaying minerals, controlling quality and writing specifications. However, trial and error was for a large part still normal procedure; for instance by Thomas Edison in his laboratory at Menlo Park. Larger firms increasingly established in-house R&D, as this was seen to be more able in combining various inputs and firm-specific knowledge. R&D came to have *two faces*, as firms were combining in-house research with external technology. There was a continuing tension among scientists in these in-house R&D labs between a desire to do pure science, and the firm's need for patents (von Tunzelmann 1995:194-202). The analysis in this thesis considers the linkages between in-house R&D and external technology in relation to knowledge development and effects on innovative performance.

By the early 20th century, the US was leading in industrial productivity, primarily because of superior organization of production and competencies in marketing. The US operations in wartime became significant for the rest of the world. The US found itself in a position to rebuild the world economy, by which measures like the Marshall Plan (1948) was put to work. The Iron Curtain came down at the same time, dividing the East and the West. In this period, the role of formal R&D rose, whereas the importance of individual inventors decreased. In-house R&D got more and more oriented towards handling complexity and idiosyncrasy of technology in the firm, while contracted-out R&D was used for routine investigation and standardization. This complementary relationship of R&D is similar to the *two faces* perspective noted above. In-house R&D departments were separated from production to be able to take on long-term perspectives. In addition, it was acknowledged that to be able to interpret and benefit from other firms' R&D, it was important to do own research in that area. Another reason was that it became common in some industries to pool patents, and to be able to take part in this pool, conducting own R&D and sharing patents was a condition. Such industries usually consist of large firms, and are described as Schumpeter Mark II. This is characterized by *creative accumulation* where barriers to new entrants are high due to the complexity of technology, long-term cumulativeness of knowledge and consequently low degree of externalities in a given industry. The contrasting Schumpeter Mark I describe industrial sectors characterized by *creative destruction*, in which innovation is largely driven by entrepreneurs and new firms, with technological ease of entry and low cumulativeness of knowledge. Such sectors are usually subject of widespread externalities (Herstad in Nifustep Rep. 4/2008, Malerba 2005). Other countries copied the two faces model with a relatively high degree of success. The exception was the UK, which seemed to be lacking the in-house ability of interpreting and benefit from outside R&D. The US expenditure on Federal research funding was massive during and after the Second World War, and universities and colleges took the lead in high-tech industries. This was partially induced by supporters like Vannevar Bush, pushing *Big Science* like the Manhattan Project (the atomic bomb) and other projects aimed at national security. Western Europe began a huge journey of catching up in the 1950s, which required major local adaptation of technology from the US (von Tunzelmann 1995:219-245). This thesis examines the cooperation between StatoilHydro and its customers, suppliers, research institutions and other companies in the oil and gas industry. Learning and knowledge development following of these relations is regarded as crucial to enhancing innovation.

From around the 1970's, progress were being made in innovation in the information and communication technology (ICT) sector. This had major implications for R&D, which saw a general increase in the knowledge-intensity of advanced industries and economies. Advances in ICT also meant a shift in technological components; from mechanical and electro-mechanical to electronic based systems, for instance in Numerically Controlled Machine Tools. Such change also necessitated improvements in software for such machinery in the high tech industry. In terms of organization, tendencies towards technological convergence (i.e. firms specializing in components used in other industries) made way for horizontal linkages between firms, a network of flexible specialization. Attention was drawn to product and process flexibility, which allowed for organizational learning. This presupposed close and informal relations, as well as formal multi-directional networks, of producers, suppliers and customers. These relations were supported by continuous improvements in ICT, which allowed for the increased sharing of knowledge and communication which became more and more independent of time and place. (Von Tunzelmann 1995:256-269) Formal and informal networks for knowledge sharing and learning are subject of interest in this thesis, as they are seen to potentially enhance innovation.

The following will consider some views on innovation processes, and some possible implications of this.

2.1.3 Innovation Processes

For policy purposes, the tidy linear model of innovation processes which assume innovation processes as a chain of causation, from research to development to production and marketing, has been favoured. The linear model thus holds scientific research as the critical element. This is however an incomplete view which need to be complemented by a different view which consider reconsiderations of steps in the process, feedbacks and reviews of existing knowledge, and that some innovations thus come about through a "messy" process of interactions. (Fagerberg et al 2005)

The linear model of innovation

The linear model of innovation has been popular since World War II, most commonly associated with Vannevar Bush's emphasis on public funding for scientific research. Having a background as the director of Office for Scientific Research and Development (which was responsible for the US military research), he argued that the key to new products and processes lay in the development of new basic research. His recommendations led to the establishment of a research council, the US National Science Foundation, and inspired many other countries to do the same, including Norway. (Godø 2008) The linear model assumes a chain of causation with science as the starting point, from which results are developed, and proceeds to production and marketing. The linear model is thus useful for those defending the interests of researchers, scientists and their organizations. (Fagerberg et al. 2008)

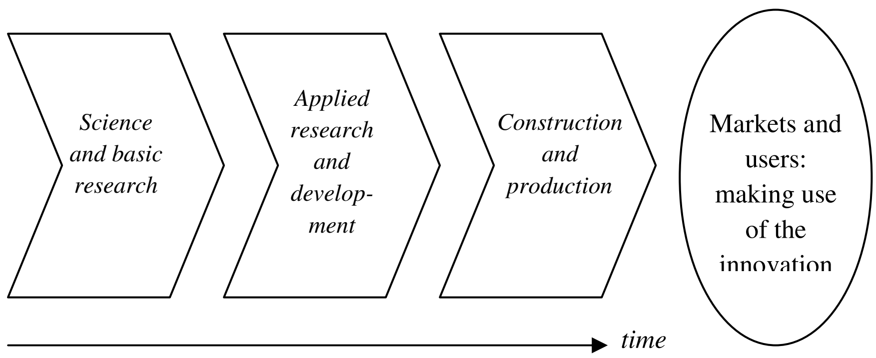

Figure 2.1 The research based, linear model of innovation (in Godø2008:51)

There are however some problematic issues with this model. Firstly, it assumes that basic science has precedence over applied science, indicating a hierarchy of scientific work. It thus assumes that basic science is the source of knowledge for applied science and society at large.

This view ignores other sources of knowledge development. The linear model has been criticized for not providing a realistic image of innovation processes, and that basic science has been credited too much to the detriment of other factors. Labelling university research as basic research and research done elsewhere in society as applied research has been commonplace, among other reasons because of widespread use of an OECD indicator which does not consider the actual content of such research. A reason for the broad acceptance of the linear model may be that people attending higher education at universities and college are imprinted this view by their academic teachers. (Godø 2008)

The model is however suitable for explaining how some radical innovations have been created during the 20th century, where the sources quite clearly have been advanced scientific research. Nuclear power, the transistor, sonar and radar, and the mass-production of penicillin are examples of this (Godø 2008). In the context of StatoilHydro, innovations on issues such as chemicals and multi-phase flows are partially fuelled by mechanisms resembling the linear model (for instance cooperation with research institutes or universities).

The interactive model(s) of innovation

As a response to the linear model of innovation, several models has been developed emphasizing the complex and dynamic interactions taking place in an innovation process. In the interactive models, the contact and interplay between a market and businesses is the most important source of innovations. One popular model is called “the chain-linked model”, developed by Kline & Rosenberg (1986). It emphasizes research and science as something taking place separate from the business, and that it has only indirect significance for innovation activities in firms. Interactive models give emphasis to how feedback from suppliers, customers or other relevant groups result in a process of development and refinement of an idea that eventually is launched on the market. These processes are complex and involving several actors with different linkages and feedback-loops, often presented neatly in a flow-chart. In reality, the processes unfolding are even more complex and chaotic. (Godø 2008)

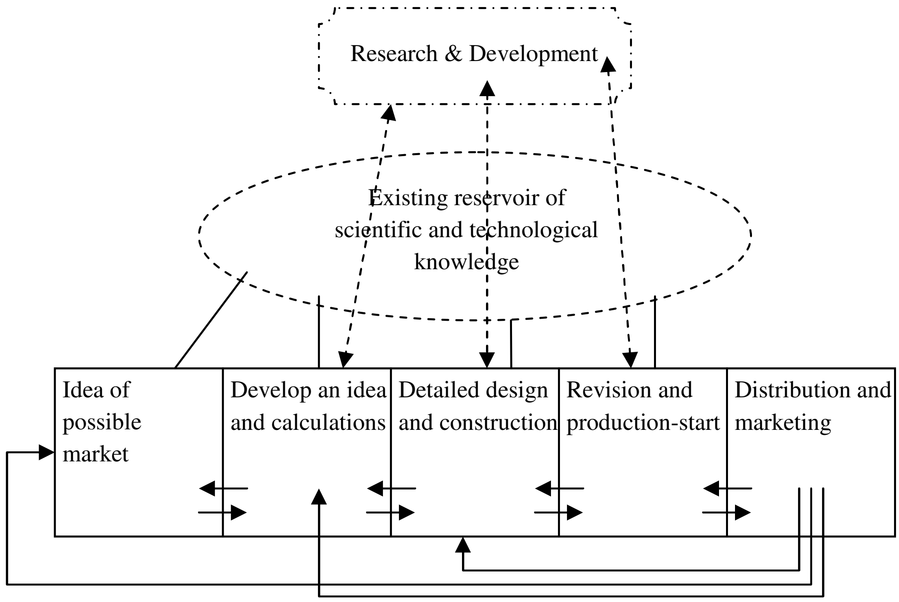

Figure 2.2 The interactive model of innovation processes, based on Kline and Rosenberg 1986 (in Godø 2008:53)

The circular, iterative character of such processes has by some innovation scholars been named "the Innovation Journey", describing the processes as a journey through a terrain which is poorly mapped and with unclear solutions (Van de Ven et al. 1999). Some interactive models label the contact between market and business "user-producer interaction", laying great emphasis on collecting and interpreting signals from markets and users as a basis for choosing direction. This is problematic, because it is often difficult to know how to interpret these signals, and the signals themselves are often blurry and ambiguous. A response to this is the user-driven model of innovation, put forward by Eric Von Hippel (1988). The model assumes that the determining source and force of creating innovations is that the innovator has an expectation about harvesting some sort of benefit from the innovation. A person who is able to articulate a need, and develop a solution to this need, will most likely expect an advantage or profit from this activity. (Godø 2008)

The model thus identifies users as the most important source of innovations, because their needs drive innovations. This view has been subject to criticism, particularly because it is lacking in explaining how radical innovations come about. The user-driven model is best suited for explaining incremental innovation. (Godø 2008) The different perspectives on the interactive model of innovation are applicable to various processes within StatoilHydro. Some relate to a user-producer interaction view (for instance cooperation with suppliers), whereas others bear more resemblance to the user-driven model of innovation (interaction with operative units).

The criticisms of the different models reflects an ongoing debate on whether the market (and users) is the most important source and force of innovations (market pull), or whether this may be attributed to technology development and research (technology push). Supporters of the market pull view generally argue that companies and private businesses should control their own innovation activities and that public authorities should limit their participation to offering beneficial regulations which does not favour any particular technology or sector. Opponents to this argue that the technology push is more important, stressing that the market offers limited opportunities towards developing innovations, particularly radical ones. They further argue that companies are not interested in developing technologies or services involving high economic risk. (Godø 2008) Mechanisms of market-pull and technology push are both relevant to processes of innovation in StatoilHydro.

Related to this debate, is the issue of path-dependence. Once a business is involved in a certain type of technology development, organizational learning and external relations reinforce the technological trajectory. Technology development can not be assessed separate from its social, political, cultural historical and ideological context. Contemporary issues in society and the internal knowledge base of a business will set a course for its technology development. This is however possible to overcome, as new knowledge is produced and diffused, people of curiosity perform experiments of trial and error, and through serendipitous factors. (Berg & Bruland 1998, Pavitt 2005) StatoilHydro has developed mechanisms through which technological trajectories are explored, with a potential of tackling path dependence.

The following provides an account of the historical context of the Norwegian oil and gas industry.

2.2 The Oil- and Gas Industry in Norway – Development

The Norwegian oil- and gas industry is relatively young compared to similar industries in other parts of the world. Search and exploration for oil and gas on the Norwegian continental shelf was not discussed and initiated before the late 1950's and early 1960's. In this period, several international companies negotiated with Norwegian authorities about the rights to explore the Norwegian continental shelf. Norway had relations to foreign trade and institutions like GATT, IMF and the World Bank, and saw a general decrease in restrictions on trade. Simultaneously, there was a fear for rising unemployment due to a large number of childbirths in the early post-war years. The climate for foreign capital was thus positive, pushed forward by state initiatives trying to accommodate such investment. During autumn 1962, American company Phillips, and other multinational companies, contacted Norwegian authorities about the possibility of engaging in exploration on Norwegian continental shelf. A major goal for the Norwegian policy was to ensure that as many companies as possible would engage in as much activity as possible on the Norwegian shelf. This was motivated by a desire to find out whether there actually was any oil on the shelf, and thus the first licence-round was initiated. (Ryggvik in Olsen & Sejersted 1997:26-32)

2.2.1 Foreign investment and national control

In this situation, Norwegian industry was discouraged from joining, partially because the authorities believed that the uncertainties and risks involved were too great. Next to nothing was done in terms of securing the transmission of specific competencies to Norwegian hands. In fact, the foreign companies were surprised by how unfavourable the Norwegian companies were treated by the authorities. Norwegian companies were awarded very modest portions of the licences. Notably, Norsk Hydro argued that Norwegian competencies on relevant technology should be a priority. [2] This argument was not taken up by the authorities at that point. By the second licence-round, Norwegian authorities requested *carried interest* agreements with the companies who were awarded licences. The Petronord-group (including Norsk Hydro), Phillips, and Syracuse accepted. Esso and the Amoco-group (with NOCO, predecessor to the Saga company) did not accept this; instead they got *net profit* agreements. The agreements in the second round also stated that the international companies should strive to use Norwegian goods and services, and if oil was found on the Norwegian continental shelf, then the companies would have to accept that the Norwegian state would take on a more active role. (Ryggvik in Olsen & Sejersted 1997:32-37)

Little was done to build Norwegian competencies in the 60's. Some attempts were made to increase geology competencies, to be better able to evaluate applications. Aker had a contract

[2] Norsk Hydro was at the time one of the oldest and largest industrial companies in Norway, and possessed wide technological competencies in chemicals and waterenergy. The Norwegian state held a majority of the shares.

on their floating rig Ocean Viking, but this was an exception. In January 1970, the Norwegian companies Norsk Hydro, NOCO and Syracuse were summoned to a meeting to discuss joint efforts towards exploration north of the 62nd latitude. Several suggestions were made, but the negotiations stranded, and the idea of a semi-governmental company was abandoned. Around the same time, a major find was done in the Ekofisk-field. The industrial committee in the Norwegian parliament lay down "ten commandments" on how Norwegian oil policies were to be executed in the forthcoming years. A main point was that national administration and control had to be secured, in order to make independent on supplies of crude oil. The state would actively support the build-up of a Norwegian integrated oil environment. In addition to this, a state oil-company would be established, to handle the business interests of the state.

2.2.2 Statoil and efforts towards Norwegian competencies

After a series of deliberations, partially due to discussions on Hydro's role, an unanimous parliament passed the bill on establishing a fully governmental oil-company named Statoil, June 14th 1972. Statoil was awarded a minimum of 50% of the shares on new blocks, amongst others a particularly promising block bordering the Brent-field on British shelf, now known as the Statfjord-field. Norsk Hydro and Saga (former NOCO) did not get equally promising blocks. At Statfjord, Mobil was awarded operator-status, under the condition that Statoil would take over as operator after ten years. Esso was also given priority at Statfjord, given that they would train a distinct explorations-department in Statoil. Actions were being made to transform Statoil to a proper integrated oil-company; however, through the 1970's it was for the most part a "paper-company", while the foreign companies did the dirty work. (Ryggvik in Olsen & Sejersted 1997:37-47)

In this period, efforts were being made to increase Norwegian education in oil-relevant areas. Geology, shipping and mining was among the major subjects to be improved. Also, the Norwegian Science Council (Norges Teknisk-Naturvitenskapelige Forskningsråd, NTNF) established scholarships to motivate engineers to go back to school. A distinct education in petroleum-engineering was started in Rogaland. However, activity on Norwegian continental shelf was predominantly characterized by Americans from top management to middle management, with Norwegians as unskilled labour at the bottom. There was grumbling in the international companies due to a high level of accidents, and low wages, particularly for foreign employees. Norwegian employees were of the opinion that the work culture brought in by the international companies was the cause of accidents and bad work conditions; conditions which frequently was a subject of contention between Norwegian employees and American foremen. Among other measures to improve conditions, the Norwegian Working Environment act was made valid offshore in July 1977. In addition, the companies were informed that in future licence-rounds, employment of Norwegian workers would be a criterion for awarding licences. (Ryggvik in Olsen & Sejersted 1997:47-50)

2.2.3 Favouring Norwegian businesses

The following 2-3 years, there was an increase in efforts to strengthen Norwegian participation in oil-related activities. A report to the Norwegian parliament (St. meld. Nr. 53 1979-1980) stated three major concerns; strong governmental engagement, a nationalisation of the activity, and national freedom in terms of timing for development, scale of production and disposition of petroleum-resources. In effect, this meant that the Norwegian companies Statoil, Hydro and Saga got much better conditions for their activities. They got the most promising blocks, and operator-status on 5 out of 8 blocks. However, Norwegian competencies were still not satisfactory. Agreements were being made with foreign companies to assist in technological challenges. There were disagreements among the state officials in the Oil- and Energy Department as to how Norwegian strategies should be developed in the forthcoming years. Some believed that Statoil should be the only company exploring and exploiting the Norwegian continental shelf, whereas others argued that collaboration with international companies would be important for a long time ahead, in so far technologies are under constant development, and the challenges in the North Sea are substantial. Foreign specialized firms were at the time supreme, but Norwegian offshore-industry was budding. The shipyards-industry, with Aker and Kværner in the front, were subject of protectionist regulations from 1975 onwards. Also, the Norwegian companies' engineering-capacity was united in Norwegian Petroleum Consultants (NPC), and an agreement with American Brown & Root as joint-venture partner was set up. This enabled them to participate actively in the development of large fields. Another condition in the fourth license-round, was that the companies were to offer Norwegian institutions and businesses research and collaboration-projects, in an effort to include Norwegian industry and researcher in technology development. (Ryggvik in Olsen & Sejersted 1997:50-56)

2.2.4 Balancing Norwegian efforts and internationalisation

By the mid-80's, Statoil's dominant position in Norwegian offshore industry was considered a liability. The company was a major base of power, and to ensure a healthy development in the years to come, state involvement was decided to be split in two. One was to be controlled by Statoil as usual, and the other was to be controlled directly by the government, called the State Direct Economical Engagement (SDØE). A result of this was that Hydro and Saga got better conditions, in an effort to create true competition between different national environments. The pro-national line that had been growing stronger during the years, now showed its potential. Norwegian deliveries to development of fields increased, and several technology-agreements were being made. The latter was a result of a strategy which rewarded companies who contributed to technology-transfer to Norwegian research and development, predominantly through performing R&D in Norway in collaboration with Norwegian actors. However, the pro-national line was partially abandoned in 1986, as state officials increasingly realised the importance of the mutual dependence between national and foreign companies. This coincided with a major fall in oil-prices, and an international tendency towards countries facilitating for multinational companies to be established in their domestic sphere. Foreign companies struggled with the conditions given by Norwegian authorities, and concessions had to be made to patch up the situation, especially concerning the taxes for oil companies. (Ryggvik in Olsen & Sejersted 1997:56-63)

The introduction of plans on the internal free market in (what is now) the European Union in 1985 made several Norwegian companies go international. For the Norwegian government, this was a dilemma. On one side, it was considered beneficial that companies could strengthen their competitive force in the international markets. On the other hand, many workplaces might be moved abroad. Then Norway became part of the European Economic Area (EEA) on January 1st 1994, which meant that several of the protectionist regulations had to be removed. Companies could now employ workers from within the EEA to the Norwegian platforms on similar conditions. Further, the technology agreements in their current form had to come to an end. The licence-directives also had to be changed. The Norwegian government no longer had the right to prioritize Norwegian companies when awarding licences and operator-status. A prevailing attitude in the Norwegian oil-industry at the time was that the petroleum industry and the oil companies were solid and competitive, and thus had no more need for protectionist regulations. As a consequence, several companies wanted to expand abroad. Statoil had in effect prepared for this for a long time, and had built a vertically integrated structure. Though it was a state company and had been protected from competition, it had been built after the model of Esso, Shell and BP. It had among other things developed a considerable R&D department, to be able to tackle challenges in the joint development projects. The remaining oil resources came to be situated in areas which were technologically challenging and competence and innovation became crucial to successful exploration and extraction. In the early 90's, Statoil allied with BP on international exploration, and took part in projects in Nigeria, Angola, Vietnam and Aserbajdsjan. Norsk Hydro and Saga did not engage in equally comprehensive internationalisation. Neither the Norwegian supplier industry had the strengths to comprehensive international expansion, due to its constellation of small and medium-sized businesses. (Ryggvik in Olsen & Sejersted 1997:63-80)

The following provides an account of the White Paper on Innovation 2008-2009.

2.3 Innovation policy and the oil and gas industry?

The oil and gas industry is characterized by capital intensive products which require large-scale infrastructure, long time-horizons for making profit, and consequently large losses if the efforts fail. Further, knowledge development and learning are crucial elements of innovation activity. National policies aimed at enhancing innovation need to take these elements into consideration. Some issues have been dealt with in white papers from the Ministry of Trade and Industry, and the Ministry of Education and Research. Previous policies on innovation in Norway have however not been quite as explicit as the recent White Paper on Innovation 2008-2009, which is the first white paper exclusively dealing with innovation.

2.3.1 The White Paper on Innovation 2008-2009

The White Paper on Innovation 2008-2009 from the Norwegian Ministry of Trade and Industry to the Norwegian Parliament provides some insights as to how Norwegian policies may tackle the challenges of innovation. It is stated that the Government has strengthened the welfare scheme which is seen to ensure a high level of education and participation in the work force, and that the economic policy contributes to good general conditions and thus innovation possibilities. One aspect of this is the strengthening of efforts in research, design, and entrepeneurship. The White Paper further declare that the Government will establish favourable conditions for; a creative society (with the Norwegian welfare state as a starting point); with creative people (made possible through a sound education, research and adaptation of working life); and creative undertakings (through the provision of support and regulations in the case of market failure). (White Paper No.7 2008-2009)

More specifically, it is pointed out that knowledge and competencies need to be strengthened. The White Paper proposes to reinforce the collaboration between education and working life, and invest in on the job training, as well as internationalisation of education. Further, it proposes a consideration of the education system with regard to future competence needs, the introduction of an action plan on entrepeneurship in education, and the further promotion of mathematics, science and technology. (White Paper No.7 2008-2009) For StatoilHydro, these efforts may be seen as beneficial in terms of securing further competencies on issues related to innovation. For the company, collaboration with educational institutions may provide the company with future employees who have a greater understanding of industrial issues, because they may get the opportunity of *learning by doing* alongside formal education. Further, sustained promotion of mathematics, science, and technology are obviously also important for a company occupied with natural resources and energy.

The White Paper further elaborates on the support to innovative undertakings. It is emphasized that adequate and simple rules are measures which may serve to save industry unnecessary costs and release resources for innovation. The allocation of research funds to environmental friendly technology is assumed to be another important measure, as well as the continued efforts towards encouraging further industrial development based on the abundant energy resources. (White Paper No.7 2008-2009) These measures are obviously relevant to StatoilHydro’s activities. Simplification of rules and regulations in an industry which has an overwhelming number of such to comply with, may release resources for innovation. Improved efforts on environmental friendly technology may also be beneficial for the company in their New Energy business area. The last point, encouraging further industrial development based on abundant energy resources, is unmistakably important as StatoilHydro is an energy company.

Another aspect emphasized by the White Paper is efforts towards research and development. Of special interest for StatoilHydro is the strengthening of the industrial doctorates system, as well as efforts related to commercialisation of research results. The industrial doctorates system provides opportunities for the candidate and the industry to learn from one another, which may enhance innovation. Further, efforts towards commercialisation of research results may be beneficial for industry as well as the individual researcher. (White Paper No.7 2008-2009)

3.0 Analytical Framework

This chapter outlines the analytical framework applied to the empirical findings of this study. The first part accounts for literature on organizations and their environment. Here I will also briefly present the concept drivers of innovation, which is central to this thesis. The concept has been developed as a result of the aforementioned literature, and through analysis of the empirical findings. The second part presents literature on knowledge development and learning, and especially how this relates to organizational practices.

3.1 Conditions for Innovation and Organizational Design

An organization is faced with internal and external conditions which influence the opportunities of that organization to innovate. The following will consider some approaches to this view, and some structural archetypes upon which most organizations are built. This provides a foundation for assessing StatoilHydro's internal and external conditions, and positioning the company in relation to some structural archetypes of organization.

3.1.1 Environment/opportunity conditions

The conditions under which an organization operates influence the opportunities of that organization to innovate. Opportunity conditions may be met with internal or external strategies (Cohen & Levinthal 1990, Malerba 2005). Innovation processes are thus contingent on their environment, and organizational characteristics need to be adapted to these conditions (Pavitt 2005). Thompson (1967) notes that an organization will try to adapt its organizational structure to the tasks it is set to solve. The environment of an organization is a source of uncertainty, but is also significant for which tasks that is important, and their internal composition. Thompson defines environment as only the conditions which are task-relevant, called task environment, i.e. the environment which is directly influencing the activities of an organization. (J. D. Thompson 1967 in Jacobsen & Thorsvik 2005: 200-2002). Alice Lam (2005) notes that: (…) contingency theories account for the diversity of organizational forms in different technological and task environments (Lam 2005:119).

One approach views different environments as defining the rules of different games, elaborating on what a task environment might consist of. Miller and Floricel state that:

(…) games are inter-organizational patterns of value creation, each of which is able to produce a steady flow of innovations. We call these patterns games of innovation because each of them is governed by "rules" that emphasize distinct ways of creating value. (…) firms find themselves in structured contexts that constrain and orient their approaches to innovation. Yet, within the given rules, games offer ample freedom (Miller & Floricel 2004:27)

The authors argue that practices must be adapted and specialized to the realities of a game's value creation, and as such, practices are contingent on their environment. Sustained practices are a result of learning to adapt to this environment, and structure the innovation journey from idea to market (Miller & Floricel 2004). The approach emphasizes different practices and organizational capabilities depending on the innovation-game a company is participating in.

The concept drivers of innovation, which I use extensively in this study, are founded on the aforementioned approaches. In addition to opportunity conditions such as market and knowledge, I have added regulations and standards as a condition which is part of the task environment. The opportunity conditions I describe are intrinsic and internal, as well as external forces. Schumpeter Mark II refers to *creative accumulation* in industries which are characterized by large established firms, where new innovators face barriers of entry particularly due to the nature of the technological regime in that industry and the market conditions. The technological regime is defining of the problems a firm will have to solve in its innovative activity, and further affects technological learning, the shaping of incentives and limitations of practices and organization, and moreover; influences the basic processes of variety generation and selection (and thus the dynamics of firms). The cumulativeness in such industries is closely related to market factors, where successful innovations with a high degree of appropriability make way for further accumulation of knowledge along distinct trajectories. (Herstad in Nifustep Rep. 4/2008, Malerba 2005)

3.1.2 Organizational typologies

The structural configuration of an organization ideally corresponds to the configuration of the relevant technological and market environment. Burns & Stalker suggested that the environment of an organization may be classified as stable and predictable, or unstable and unpredictable. Following of this, organizations may be grouped into one of two main types; mechanistic and organic. Mechanistic organizations are typically rigid structures in stable and predictable environments, characterized by functional differentiation, hierarchical structures of communication, control and authority, and a tendency towards vertical interaction between employees. As a contrast to this, organic organizations are more fluidly structured as a response to unstable and unpredictable environments, and characterized by individual tasks adjusted and solved in interaction with others, a network structure of communication, authority and control, and interaction and communication which is horizontal. Burns and Stalker also note that even though the typologies are polar, some organizations contain a mixture of both. (Burns & Stalker 1961, Lam 2005)

James D. Thompson builds on Burns & Stalker when he argues that certain types of organizational structures correspond to their respective task environment. He uses a four-box diagram with two dimensions to separate four main types of task environments; (1) degree of homogeneity/heterogeneity in the environment; and (2) degree of stability/dynamic.

	The environment is:	
	Stable	Dynamic
Homogeneous	X	X
The environment is:		
Heterogeneous	X	X

Figure 3.1 Thompsons (1967) two dimensions of the environment (in Jacobsen & Thorsvik 2005)

A homogeneous environment (1) represents an environment in which the organization has few other actors it has to relate to, and these actors are relatively similar. The organisation may thus easily acquire a general idea of actors and events in the environment which are crucial to the business. These characterizations correspond to a Schumpeter Mark I pattern, wherein the technological regime offers high technological opportunities, low appropriability and low cumulativeness. However, a Schumpeter Mark I pattern generally denotes a pattern of rapid changes and high uncertainty. A stable environment (2) refers to an environment which does not change a lot over time, which means that changes in the environment are relatively easy to predict. Technological change in stable environments tends to follow defined trajectories, in economies of scale, where knowledge development follows a cumulative pattern, and barriers to entry are generally high, analogous to Schumpeter Mark II. A Schumpeter Mark I pattern of innovation is generally found in homogeneous and dynamic environments, whereas Schumpeter Mark II tends to be found in heterogeneous and stable environments (Malerba 2005, Herstad in Nifustep Rep. 4/2008). Thompson argued that the degree of homogeneity will influence the degree of differentiation in an organisation (i.e degree of specialisation), and the degree of stability will influence whether decision-making is made centralized or decentralized. This is well in line with the Schumpeterian view. Thompson's perspective builds heavily on Burns and Stalker's (1961) typologies on organizational structures; mechanistic and organic structures. This roughly corresponds to stable and homogenous environments, and dynamic and heterogeneous environments respectively. (Thompson 1967 in Jacobsen & Thorsvik 2005:200-202)

Mintzberg (1979) builds among others on Thompson (Thompson 1967 in Jacobsen & Thorsvik 2004) and Burns and Stalker (1961) when he presents five structural archetypes of organizations. Of these, the divisionalized form and the adhocracy are of special interest. Both relate to heterogenous environments, but the divisionalized form is assumed to correspond to a stable environment, whereas the adhocracy is characterized by a dynamic and changing environment. The divisonalized form is characterized by "quasi-autonomous entities" that are loosely connected by a central administrative structure. The adhocracy on the other hand, is often based on projects, is flexible and able to deal with dynamic and complex conditions rapidly. It is stressed that the strengths of the divisionalized form is that it is able to concentrate on highly localized issues, A weakness is however that it often performs correspondingly localized R&D to the detriment of central R&D, and there may be competition between divisions which inhibit knowledge sharing. The strengths of the adhocracy lies in its abilities to learn and unlearn quickly, which makes it highly adaptive and innovative. A weakness is that it is unstable and short lived. The structural archetypes are ideal types, and that no "pure" form is found in an organisation. Rather, organisations in real life are a mix of two or more types (Mintzberg 1979 in Jacobsen & Thorsvik 2005:99-107, Lam 2005).

Matching the organizational structures with its environment is a matter of learning. Pavitt (2005) has argued that:

(…) innovation processes involve the exploration and exploitation of opportunities for new or improved products, processes or services, based either on an advance in technical practice ("know-how"), or a change in market demand, or a combination of the two. Innovation is therefore essentially a matching process.(Pavitt 2005:88)

This can be seen in relation to the concept drivers of innovation (i.e. the task environment and opportunity conditions), in which exploration and exploitation of opportunities roughly translates to development of knowledge and organisational capabilities, whereas market demand is translatable to operative. The matching process is thus the process whereby the organization identifies and develops different types of knowledge to respond to the drivers of innovation. StatoilHydro is continually going through a matching process which is informed by assessments on the task environment and the corresponding organizational structures.

3.2 Knowledge and Learning

The following provides a framework for considering modes of learning and innovation, types of knowledge, and some organizational practices linked to these.

3.2.1 Modes of learning and types of knowledge

Organizations change and adapt to their environment, and such adaptation is a process of learning and developing knowledge about internal and external conditions. The following accounts for two modes of learning and innovation and types of knowledge. Modes of learning and innovation and organizational practices following of these are central to the matching processes taking place in StatoilHydro.

Science, Technology and Innovation & Doing, Using, and Interacting

One approach suited to discuss different types of learning and innovation is put forward by Jensen et al. They consider two different modes of learning and innovation, the first being the Science, Technology and Innovation mode (STI), and the second being the Doing, Using and Interacting (DUI) mode.

The two modes of learning and innovation may be seen as relating to dichotomies of knowledge. Tacit and codified knowledge and local and global knowledge are typical ways of dichotomizing types of knowledge. Tacit and local knowledge is usually associated with the DUI mode, whereas codified and global knowledge is associated with the STI mode. However, for practical purposes, these may be linked to a set of distinctions which is a little more elaborate: know-what, know-why, know-how, know-who. The STI mode is typically related to the first two, as it is concentrated on science-based learning. The DUI mode is on the other hand related to the latter two distinctions, as know-how and know-who to a great extent is based on skill, expertise and learning by interacting (and knowing-who by interacting). It is however worth noticing that these are ideal types of learning and innovation, and that tacit and codified elements are to be seen as complementary poles on a scale (Jensen et. al. 2007).

The STI mode of innovation and learning is often related to knowledge that may be written down and passed to others, for instance through books, manuals or scientific journals. This knowledge may be absorbed by others, but this is not an automatic process of knowledge transfer; "(…) a prepared mind" is needed (Jensen et al 2007:683). Technology is often supported by knowledge derived from science, and is thus incorporating generic, science-like understanding (know-why). Knowledge related to particular artefacts, and not generic knowledge, is the main difference between technology and science. The STI-mode of innovation and learning is mainly related to how firms use and further develop this science-like knowledge in their innovative activities. Codification of knowledge in order to communicate with other scientists is thus an important feature of solving problems in the STI-mode. (Jensen et al 2007)

The DUI mode of innovation and learning is related to practice in technological fields which is not necessarily written down or readily codifiable. An employee may have learnt that one way or the other simply "works", without any considerable understanding of why. Such knowledge is often learnt on the job, and "(…) enhances the skills and know-how of their employees and extends their repertoires. (…) complex processes may involve interaction within and between teams and may result in new shared routines for the organization" (Jensen et al 2007:684). Such practice may also involve linkages to actors from outside the company, such as suppliers and customers, and are often informal. DUI-learning is related to tacit and localized knowledge in the form of know-how and know-who. It is possible to facilitate such learning through organizational structures and practices that promote teamwork, problem-solving groups, and rotation of jobs. This is referred to as learning by doing, using and interacting. (Jensen et al. 2007)

Analytic/synthetic knowledge

The DUI and STI modes of learning and innovation account for different approaches to learning and innovation. This may result in different types of knowledge, by Asheim and Gertler (2005) coined analytic and synthetic knowledge. The authors note that the different types of knowledge involve different mixes of tacit and codified knowledge, with different codification possibilities and limits. They further relate to different qualifications, skills, organizations and institutions, and innovation challenges and pressures. (Asheim & Gertler 2005)

A synthetic knowledge base is dominant in industrial settings, where there often is a need for solving specific problems that come up through the interaction with customers and suppliers. Synthetic knowledge most commonly refers to application or novel combination of existing knowledge. Tacit knowledge is important because synthetic knowledge is often produced through learning by doing, using and interacting (the DUI-mode), activities requiring a high degree of concrete know-how, craft and practical skill. (Asheim & Gertler 2005)

On the opposite side, analytic knowledge is prevailing in settings where scientific knowledge is important, where problem-solving often take the form of creating knowledge through basic and applied science, and systematic development of products and processes. Analytic knowledge is characterized by the production of formal models, codified science and rational processes. Codification of knowledge is essential because inputs are often based on reviews of existing studies, and the generation of knowledge is based on application of widely understood and shared scientific principles and methods. Processes of knowledge are highly formalized and concerned with documenting results through reports, electronic files, and patenting. (Asheim & Gertler 2005)

Related to analytic and synthetic knowledge is the concept of knowledge spillovers, which suggest that innovation processes are spatially concentrated, even if codified knowledge is central in the activity. Knowledge spillovers emphasize the social aspects of innovation processes, such as the informal social networks of scientists and other workers. (Asheim & Gertler 2005)

3.2.2 Organizational practices for learning and knowledge development

Related to the two modes of learning and innovation and synthetic/analytic knowledge, we find some organizational practices. The practices may be seen as supporting the aforementioned types of learning and knowledge through providing flexibility and (often) decentralization of decisions.

Jensen et al. (2007) consider four organizational practices; interdisciplinary workgroups; quality circles, systems for collecting proposals; and autonomous groups. Clegg et al. (2005) notes that organizations tend to develop intraorganizatonal and external capabilities of learning and knowledge development, which often is organized as cross-functional and cross-boundary teams. Organizations are becoming more interactive horizontally and vertically. This has by some been termed *postbureaucracy*, *network organization* or *virtual organization*, emphasizing absence of formal rules and hierarchy, and a more or less loose network structure which is supported by information technology. (Clegg et al. 2005:96-98)

Wenger notes that learning is a process of social participation which includes four components; community, practice, identity and meaning. The author uses the term *communities of practice* to refer to this relationship of components. For an organization, the term communities of practice:

> *(…) means that learning is an issue of sustaining the interconnected communities of practice through which an organization knows what it knows, and thus becomes effective and valuable as an organization. (…) if we believe that people in organizations contribute to organizational goals by participating inventively in practices that can never be fully captured by institutionalized processes, then we will minimize prescription, suspecting that too much of it discourages the very inventiveness that makes practices effective (Wenger 1998:8).*

This is a rather effective argument for establishing interdisciplinary workgroups and similar practices for innovative activities, in so far they are able to facilitate community building and give members access to resources for learning, enabling action and decision-making "(…) which fully engage their own knowledgeability" (Wenger 1998:10).

Lazonick notes that traditionally, Japanese firms have been integrating shop-floor workers in organizational learning, whereas companies in the US tended to maintain a sharp segmentation in the labour force. This cross-functional integration is seen as important in producing an integrated skill base (Lazonick 2005:42-45). Demarcations between employee groups are assumed to be softer in the J-form of organizational integration, which may facilitate more effective communication in the organizational layers. People in one layer has a general knowledge of each other and can communicate with people in the layer over or under, regardless of departmental boundaries. This is a contrast to the bureaucratic line of communication in the US form, where an employee at a given level goes through a hierarchical tree of superior officers to reach an employee at the same level in a different department. (Dertouzos 1989:97) Increased horizontal and vertical interaction through various types of practices such as teams and workgroups are assumed to enhance learning and knowledge development.

3.2.3 Cooperation and search

Cooperation between companies in its most intense form includes a commitment to the sharing of existing knowledge for the purpose of developing new knowledge. This process points to how a company's boundaries may be porous in two ways; inside-out and outside-in. Cooperation may provide opportunities to access complementary resources, and to internalize external knowledge spillovers. Choosing to cooperate rests on several reasons; access to proprietary technology, access to skills, know-how and other tacit knowledge, cost and risk sharing, and specialization. It also requires trust, insofar the companies involved attempt to develop mutual understandings of what is to be achieved and expose their knowledge. Cooperation may be subject to lock-in, due to the intense engagement and irreversible investments made. (Vision Eranet 2008:15, 32, 62)

Search on the other hand is essential for businesses to gain an overview of what goes on in the industry beyond their cooperative partners, and is thus usually broad. (Vision Eranet 2008)

A company interface with external actors and exchange information and knowledge to a varying degree with these actors. Notably, this means that the boundaries between the firm and its environment becomes more porous and "(…) embedded in loosely coupled networks of different actors, collectively and individually working toward commercializing new knowledge" (Laursen & Salter 2006:132) Companies search their internal and external interfaces to gain knowledge which may be applied to innovative activities. Breadth in relation to search practices refers to how many sources or search channels that a firm uses in its innovation (explore knowledge), whereas depth refers to the intensity of such relations, i.e. how the firm draws deeply (exploit knowledge) from a given channel. Further, it is argued that a firm will go through a process of trial and error with a given search channel, in order to learn how to absorb knowledge from this source (Ahuja & Katila 2002, Laursen & Salter 2006).

An hypothesis in the search-perspective is that some firms tend to "over-search", meaning that at a given point, efforts towards search exceeds the payback in form of applicable ideas and knowledge. It is suggested that a reason for this is that interaction with a source needs to be sustained over time, because search not only involves scanning wide numbers of sources, but also to learn and draw knowledge from these sources (Ahuja & Katila 2002, Laursen & Salter 2006:135-136).

One article on knowledge search considers how the maturity of knowledge in a firm influences the search for new knowledge. It suggests two opposite propositions; that a firm's old knowledge base may be helpful in enhancing innovation, and that this may function as a supplement to more recent knowledge on issues relevant to enhancing innovation. The other proposition suggests that old knowledge may hurt innovation, because it constrains the adaptation to the environment and inhibits learning. Moreover, matching the organization with its environment through capacity building in emerging areas and reduced costs of search is put forward as an explanation for how new knowledge may enhance innovation. (Katila 2002)

A major point in the article is that the propositions of how old knowledge may help or hurt innovation are not contradictory, but that they relate to different kinds of knowledge. A firms *search-space* is divided in three; search of internal knowledge, search of industry knowledge (spillovers) and search of outside-industry knowledge. Relevance of the age of knowledge depends on where the firm searches. The article puts forward that relying on old (mature) knowledge from competitors will harm innovation. Further, internal (firm-specific) knowledge takes a curvi-linear relationship to innovation. Mature knowledge stemming from external areas (outside-industry) has a positive effect on innovation, and is further enhanced by increased diversity of the external search. In other words, old external knowledge can be a source of new innovations. (Katila 2002)

Summary:

The analytical framework which has been presented provides insights as to how StatoilHydro is organized in relation to the drivers of innovation, and how this is sought to be met through modes of learning and innovation and organizational practices.

4.0 Research Design and Methods

This chapter will provide an account of the research design and methods applied in this study. This includes formulation of research questions, data collection, population sample and chosen variables. Some points on the codification process, reliability and validity of the study will also be discussed.

4.1. Research Design

A research design refers to how a study is formed in order to answer the research questions. Yin has labelled this an action plan, noting that: "(…) a research design is *an action plan for getting from here to there,* where *here* may be defined as the initial set of questions to be answered, and *there* is some set of conclusions (answers) about these questions" (Yin 1994:19). He proposes a set of components which are particularly important in case studies: (1) a study's questions, (2) its propositions, if any, (3) its unit(s) of analysis, (4) the logic linking the data to the propositions, and (5) the criteria for interpreting the findings. (Yin 1994:20)

4.1.1. A case study based research design

Studying processes of learning and knowledge development in one specific company calls for a case study approach. Case studies are suitable for understanding complex social phenomena where the investigator has little or no control over events. It "(…) allows to retain the holistic and meaningful characteristics of real life events – such as individual life cycles, organizational and managerial processes, neighbourhood change, international relations and the maturation of industries" (Yin 1994:3).

4.2. Population and Sample

"A case study may be understood as the intensive study of a single case where the purpose of that study is – at least in part – to shed light on a larger class of cases (a population) (Gerring 2007:20). The unit of study (the sample) is not entirely representative of the population

(Gerring 2007). Propositions put forward in this study relate to a company in the oil and gas industry, but can be applied to companies residing in other industries.

In order to find a sample unit, an inquiry was forwarded to the Industrial Park at Herøya in Porsgrunn. Representatives of the present StatoilHydro research centre responded positively. This resulted in a series of meetings with key people in the research organization, where the topic of study and possible respondents were discussed. Respondents have been selected progressively, based on informal talks with people working with organizational issues related to innovation in StatoilHydro. This approach is analogous to a snowballing approach (Johannesen & Tufte 2002). In order to gain a broader empirical base and understanding of the activities, respondents were chosen from two different research centres within StatoilHydro, holding different positions. Some work as scientists and innovators, others as administrative staff, and others again as managers with responsibilities for innovation processes. Due to limited time and large amounts of data, respondents have only been chosen from the research community in StatoilHydro..

4.3 Data Sources and Collection

The empirical material of this study was collected through five individual in-depth, semistructured interviews, and five individual informal, unstructured interviews. In addition to this one observation of a meeting place for scientists and operative units was done, as well as documentary analysis of documents related to innovation strategy and values. Using multiple sources of evidence is assumed to strengthen the validity of a study; insofar the sources all address the same facts. Individual sources of evidence may possess different strengths and weaknesses, and should be considered complementary to one another. Using a process of triangulation of data sources will significantly enhance the quality of a case study (Yin 1994).

A total of ten people were interviewed, all of which done face-to-face. The respondents were chosen because of their extensive knowledge on innovation processes and knowledge development in StatoilHydro. All interviews were done in the period from October 2008 to January 2009. Of these, five were semi-structured interviews lasting between one hour and two hours. A guide of questions was used during the interviews, and new information that came up was used as a basis for pursuing interesting themes. The interviews were thus focused, but provided flexibility for asking open-ended questions about facts that came up during the interview and the respondent's thoughts on this matter. In some of the interviews (and indeed through the informal meetings prior to the interviews), the respondents provided insights to themes and topics which proved highly useful for later data collection (Yin 1994). The same is true for the last five interviews, which were more open-ended and flexible. These interviews lasted between half an hour and two hours. Due to issues of confidentiality and strategy, the respondents are kept anonymous. This is also the case for some of their expressions on topics related to innovation projects.

Some of the empirical data stem from direct observation of people and activities in the research organization of StatoilHydro. I was a guest at the Porsgrunn Research Centre for approximately three weeks while doing interviews. I was set up with an office of my own, and assigned a contact-person in case I had any general questions. This period proved highly useful for me. I had the opportunity to do interviews, go back to my office and do notes or work on other issues of the research. If any questions arose, I could just go and knock on a door. This period thus allowed for some general observation of the inner workings of the research centre. Further, I experienced that as soon as an interviewee learnt that I was in fact working there for a period, and had also gone through the internal safety-course, the interviewee suddenly seemed to be a lot more enthusiastic about answering questions and helping me out in gathering information. I also visited the Trondheim Research Centre for one day to do interviews and participate in an Innovation Café. At the Centre I met up with people from the Porsgrunn Research Centre who guided me throughout the day. My guides, and general observation of activities and specifically the Innovation Café provided highly useful background information and information specific to the Café. In addition to this, some observation was done through establishing contact and doing preliminary research such as informal talks and visits. I developed a thematic observation-guide for the Innovation Café based on prior knowledge provided by some of the respondents. The guide was a big help in collecting information on various themes during the observation. The general observation through various contact with StatoilHydro, and the observation of the Innovation Café has been invaluable to the study. Contextual information provided during interviews has been easier to capture and understand due to this observation, and the analysis has benefited greatly from this. Observational evidence may add new dimensions for understanding contexts or phenomena, and provides additional information. (Yin 1994)

Collecting empirical data through written sources has been an important part of the data collection, especially in the early phases of the research design. The research questions and the interview guide has benefited greatly from these sources. Reading documents on innovation policy issues, administrative and strategic documents, websites, and newspaper articles has provided information about activities, actors and technologies related to innovation in StatoilHydro. This has also supported the understanding of empirical findings and subsequent analysis. Yin notes that when using documents as a source of data collection, it is important to be aware of any possible bias on the author's part (and own bias related to type of source). Although documents may be biased, or meant for a different audience that the researcher, they may still provide helpful information that may strengthen or enhance information from other types of data collection. (Yin 1994)

4.4 Validity and Reliability

An important aspect of a research design is whether it takes into account issues of validity and reliability. Yin (1994) divides validity into three subcategories; construct validity; internal validity and external validity.

Construct validity is concerned with whether the investigator has established correct operational measures for the concepts being studied. Three strategies has been used to increase construct validity; (1) the use of multiple sources which all address the same facts, i.e. triangulation; (2) establishing a chain of evidence, i.e. allowing an external observes to trace empirical evidence from initial research questions through case study protocol to conclusion; (3) key respondents should have an opportunity to review the draft case study report. *Internal validity* is for this study a matter of whether the investigator makes inferences based on events that has not been directly observed. An event is assumed to be a result of an earlier occurrence which the investigator has come to know of through interviews or documents. A strategy of pattern-matching is one way of addressing internal validity, where an empirical pattern is compared with a predicted one. If the patterns match, this may strengthen the internal validity. *External validity* relates to whether a study's findings may be generalizable beyond the current case. As noted above on population and sample, findings in this study are analytically generalizable, in so far propositions may be tested on other firms and industries. The centre of attention for this study is learning and knowledge related to drivers of innovation in one company, but it is possible to consider some implications of these propositions for firm strategies in other industries. This as what Yin refers to as *analytical generalization*, not to be confused with *statistical generalization*, which is a whole different matter. Analytical generalization means attempting to generalize a particular set of results to a broader theory. (Yin 1994)

Reliability deals with the issue of whether an investigator copying the same procedures on the exact same case would arrive at the same findings and conclusions. The goal is thus to reduce the occurrence of errors and biases in the study. Ensuring a high degree of reliability has been sought through developing an outline of the thesis, a case study protocol, and interview guides. (Yin 1994)

4.5 Data Codification and Analysis

Interviews and observation means that huge amounts of data are collected. This data need to be structured somehow as to provide overview and some order prior to analysis. This should be considered prior to the collection. Implicit and explicit categories have been identified in the data, and have made it possible to sort the data into two matrix systems, one for each research question. Such coding is the foundation for what comes later in the analysis. Analysing the data in this study has been a process of alternating inductive and deductive processes. The data has been compared and subjected to processes of abstraction, which has opened them for conceptualization and further comparison with theoretical frameworks. Such processes bear resemblance to the grounded theory approach. (Punch 2005)

5.0 Drivers of Innovation

This chapter will present main findings and an analysis of the collected data, using relevant literature. Based on theory introduced in the previous chapter, and empirical data from the two research centres, the emphasis will be on external and internal conditions relevant to innovation. The research question I will be discussing is (1) “What drivers of innovation is StatoilHydro operating under, and what kinds of needs for knowledge development follows of these?”.

The research question will be answered by assessing the external setting of the two chosen research centres in StatoilHydro. I have distinguished three main categories of drivers of innovation; *Operative Needs; Standards, Regulations and Social Demands,* and *Knowledge*. These will be dealt with separately, and discussed in light of relevant literature, specifically regarding external environments and organizational design. The last section of part one of the analysis will consider organizational aspects linked to the drivers of innovation and needs for knowledge development in the industry.

5.1 Drivers of Innovation

By the concept drivers of innovation I refer to a set of external and internal factors which condition the needs for knowledge development in the organization. These drivers constitute the major factors of the environment within which an organization exist, and pose specific challenges that the organization must be able to deal with, in order to succeed with their innovation. Innovation processes are thus *contingent* (Pavitt 2005:87). This means that corresponding types of knowledge need to be created, developed and sustained, if the organization wishes to succeed in this environment.

Thompson (1967) defines environment as only the conditions which are task relevant. The drivers of innovation may be seen as a general analogy to the task environment, but with one distinction; a driver may be internal or intrinsic as well as external (J. D. Thompson 1967 in Jacobsen & Thorsvik 2005: 200-2002). The research centres are situated within a large organization, and have linkages to actors and deal with challenges coming from within StatoilHydro and outside. Thus it may be argued that their task environment is both internal factors and circumstances in the company, and whatever lies outside the boundaries of the company. This is in line with literature emphasizing how organizations co-evolve with their environments (Van den Bosch et al 1999). I have separated three broad categories of drivers of innovation; Operative needs; Standards, Regulations and Social Demands; and Knowledge. The issue of contingency on the environment has also been labelled opportunity conditions, and the general framework of drivers of innovation is partially built on this (Cohen & Levinthal 1990, Malerba 2005). The Operative Needs category is thus based on market conditions, and the Knowledge category is based on technological opportunities. In addition I have added Standards, Regulations and Social Demands as a category, to highlight the importance of these issues as opportunity conditions. These are merely analytical categories, as all three are by nature interrelated and to a varying extent overlapping. Especially the Knowledge category may be seen as somewhat intrinsic in Operative Needs and Standards, Regulations and Social Demands. I have however chosen to keep this as a separate category, to highlight how knowledge may act as an individual driving force requiring more knowledge to be developed. The three categories constitute the task environment of the research centres.

The following section will identify operative needs, and how they may influence needs for knowledge development, and consequently research and innovation.

5.1.1 Operative Needs

StatoilHydro is involved in a vast range of activities throughout the value chain. One of the major tasks of the research centres is to provide support to the various activities in the business areas; Exploration and Production Norway, International Exploration and Production, Natural Gas, Manufacturing and Marketing, Projects, and Technology and New Energy. One of the respondents stresses the importance of technology development to face the upcoming challenges in the oil-and gas sector:

> (…) *I will put forward technology and expertise as extremely important. There will be greater challenges in the oil-sector… greater depths and oilfields, and thus technology is essential to manage the challenges which will arise. So something has to come about in terms of development and innovation… I think that is the most important point actually.*

The statement emphasizes technology and expertise as crucial. It points out that the characteristics of exploration and production will change, and that this will give rise to a change in the challenges the companies are faced with. Development and innovation is thus brought up as an answer to the new challenges. StatoilHydro is moving internationally, and this poses new challenges for the company. A respondent elaborates, highlighting that StatoilHydro believe they can contribute. Participation in fields like Shtokman in the Arctic, great depths outside Brasil and the Gulf of Mexico, oilsand in Canada and energy sources like windmills is pointed out as areas where the company may provide novel solutions. Another point is that going internationally means that the company is faced with different cultures, political regulations, and a need for local suppliers. It is further argued that:

> *A business will always have an eye for new ways of making money; this is a kind of a driving force. If you look at our industry in general, the large oilfields are generally found and in production, or they are situated in areas that are difficult to access. (…) Firstly, it is an important driving force for the company to develop itself. The second point is that we see that the Norwegian shelf has a more limited potential for development than it had before. And then we look at where we can contribute.*

This business development is one of several factors for development and innovation. Operative units breaking new ground will obviously have a need for new knowledge and technology. This has been the case also in projects on Norwegian shelf. For instance, for the projects Snøhvit and Ormen Lange, radically new solutions had to be developed. This was made possible partially due to extensive research on multiphase-flows.

However, a lot of technology development is based on improving existing installations and technology. Several of the respondents note that the pace in the oil and gas sector is quite slow; indeed it is described as conservative. One describes it as bringing a tankship about; it is not easy, it takes time… It is acknowledged that sometimes larger changes occur, but this is not common. The slow pace of the industry is explained as a result of the large investments needed to build out fields and keep operations running. If something goes wrong, there are large economical losses. Risk assessment and security is put forward as another explanation. Introducing a new technology without adequate analysis may result in accidents or unforeseen events, and this is obviously not desirable. There are however a few companies which are more innovative than others, the respondent notes, and StatoilHydro is benchmarked as one of the top companies in the industry regarding innovation.

As Thompson (1967) has argued, the environment influences the tasks of an organisation. A researcher notes that one of the most important points in doing innovation is to understand what kind of needs the organization actually has. Having a very clear definition of a problem or challenge is incredibly important. At the research centres, there is an ongoing close cooperation with field units and suppliers. This is explained as due to the need for information on what kinds of issues that is pertinent in the field, what kinds of problems they deal with, and thus what topics the research centres should be working on. Collaboration between business units within the company is underlined as crucial to obtain new knowledge on industry issues.

It is noted by a respondent that there is a tension between fundamental research and what takes place on a platform or a production unit. There is sometimes a vast distance between what happens in a field unit, and what a researcher in a research centre wants to test and develop. For a manager on a platform, there are plenty of things to handle, and thus there may be a barrier for some to allow for new technology to be implemented and tested. Clayton Christensen argues that this is a major dilemma for companies: When should the traditional practices be abandoned to make way for radical innovations? Or how does one know that an innovation will fail? (Christensen 1997). Being in an industry which relies heavily on cumulative knowledge, there is a great risk of path dependence in technological trajectories (Christensen 1997, Dosi 1982). This may be overcome, for instance through environmental regulations which force the companies to develop radically new technologies. Overall, there seems to be a general agreement amongst the respondents that feedback on operative needs is one of several important bases for deciding the direction of work in the research centres, and consequently innovation projects.

For the category Operative needs, it is stated that the company is moving more and more internationally and thus the characteristics of exploration and production change. This calls for more knowledge on cultural issues in the countries where the company operates, as well as knowledge of laws and regulations. Further, this means that more knowledge on business development needs to be developed, to face the new conditions. In addition to this, domestic and international operative units continually undergo risk assessments and security analysis. To ensure high quality of these evaluations, it is critical to continuously improve and develop tools for analysis and assessment. By name of the category, it is intrinsic that operative units need knowledge on operational issues that are grounded in scientific, organizational, cultural, social and business related topics.

5.1.2 Standards, Regulations and Social Demands

StatoilHydro has several external actors which they need to relate to somehow. Of these, some are governmental bodies regulating operational activity and maintaining industry standards. Others serve as lobby groups and try to influence these governmental bodies and the oil companies. In addition to this there are transnational political agreements, for instance the Kyoto agreement, which influence national policies and the confines of the oil and gas industry. A researcher remark that there are few other companies, except StatoilHydro, that directly or indirectly has been subject to such a large amount of political regulations. This is also notable when the company enters a country: "(…) In a way, for better or worse, we become an actor in a situation where we often are appointed the role of a successful national oil company"(R3). This is explained as somewhat problematic in some cases, but the company tries to adapt to the external factors of the current country. This is put forward as an advantage, as these external factors are important for technological development, and thus function as a driving force.

There are different actors to relate to when it comes to regulations and standards for installations, security and products. For instance, sometimes approval is needed by the Norwegian Petroleum Directorate, and fuel-stations for the pilot project on hydrogen-cars must be approved by the Directorate for Civil Protection and Emergency Planning. There are also internal groups working on issues related to health, environment and security (HSE). In an industry which has seen several serious accidents in its early history, there are many governmental regulations on HSE.

A respondent comments that while there are a lot of regulations to adhere to, there is in some cases of new technology a lack of such. Certification agencies must sometimes have help to be able to do their work, because the technology is so new that no regulations exist for it. The hydrogen cars and the fuel stations are used as an example:

> *(…) storing hydrogen, how to store it in tanks. The other is safety in the fuelling process, what parts fit together to get it* (the fuel) *over to the car and regulations on this, user-friendliness and demands on that part. I think they struggle a lot, the certification authorities, because they don't have anything to start with. So the industry has to provide guidance, to make these things happen. If not we will have a kind of evil circle of not getting started. The dilemma is that if one wants something to*

> *happen, one need to do a bit of trial and error to get data to be able to standardise a product*

This situation of having or not having regulations to adhere to puts the industry in a special situation. On one hand, they have guidelines in how solutions should be, which in some cases may act as a restraint on innovative efforts. On the other hand, where the company is breaking new technological ground, this may serve as an opportunity to think outside the box, and in fact participate in bringing about regulations for this technological field. Various forms of learning are a crucial factor in this situation. Types of learning and organizational practices will be elaborated in the second part of the analysis. In terms of regulations driving innovation, the potential of ground-breaking innovation may serve as a carrot.

Needs for knowledge development are also identifiable in the efforts towards reducing emissions. A researcher argues that the Norwegian government is very strict when it comes to emissions, and this means that StatoilHydro has to be innovative on that area, to be able to produce oil in the North Sea. The CO2 issues changes the framework conditions, meaning that the company has to operate in other ways than it would have done ten years ago. He further notes that this is not necessarily a negative consequence:

> *(…) this is actually a competitive advantage in latter phases, because we see that Norway is a country leading the way as an example, and others follow, an then we already have the technology in place. It is just as much a business opportunity as a disadvantage. In the short run it is a disadvantage because one has to invest more, but in the long run it is a business opportunity.*

It is quite explicitly expressed here that the strict regulations are an important driver of innovation. The regulations also mean that the company is forced to investigate technological opportunities that it might not have done otherwise. This highlights a need for knowledge in the scientific disciplines which may be applicable in these new technological opportunities. A respondent emphasizes the role of the government in the Mongstad test centre. The test centre is a collaborative project between StatoilHydro, Vattenfall, Dong Energy, Shell and Gassnova SF, aimed at developing knowledge on carbon capture and storage (CCS). The Norwegian government has agreed to support the centre financially, covering some 80% of the costs. He tells that this is very important in order to tackle the CO2 challenge, because the government has been able to identify main issues in the industry, and then managed to make industrial actors work together to solve the tasks ahead. This will hopefully provide important insights which may be used for future innovations on CO_2 challenges. Regulations, standards and social demands are thus an important force for driving innovation, and as mentioned above, demonstrate some distinct needs for knowledge development.

For the category Standards, Regulations and Social Demands it is noted that regulations and standards are a major factor in technology development. Governmental and HSE standards and regulations require, first of all; knowledge on this vast field of regulations and standards, and secondly; competencies in how to interpret and then handle different regulations. Thirdly, as respondents have noted, there are new technological fields in which the regulatory authorities have not yet been able to generate regulations. This means that companies and authorities may contribute to develop regulations jointly. In addition, when new regulations arise there may be a need to explore new domains of knowledge and technological opportunities to be able to respond to these new regulations. An example here is more rigorous regulations on emissions and subsequently the efforts on CCS technology at Mongstad.

5.1.3 Knowledge driving Innovation

Given the broad range of activities within StatoilHydro, there is a need for people within many different academic disciplines. Different types of knowledge are crucial in enabling people to perform activities within the various business areas. One respondent emphasizes the importance of strong organizational capabilities in ensuring communication and hands on expertise. Another respondent point out that cooperation with suppliers is both a way of easing acquisition processes, and a way of improving knowledge on a product and its supplier. This enables StatoilHydro to easier see how that product may or may not be implemented in a development-project.

Linkages to universities and research communities are also important sources of knowledge, and critical for development and innovation:

> *(…) I believe that the most important role the government can have in relation to innovation, is to make sure that the fundamental competencies are in place. This means that the universities are doing well and that they actually get the resources they need to stay on top and climb further on university rankings, and that the research communities get basic funding, so that they can develop competencies, try to identify*

> *project-ideas, product-ideas, which they can market to the industry. (…) it is really the businesses' role to be innovators. So the most important thing the government can do is to make sure that we have skilled, competent people.*

This illustrates how knowledge is seen as a prerequisite for enabling innovation. It is also seen as a type of driver for innovation, insofar it is stated that research communities may market ideas to the industry. The respondent is also stating that there are several aspects of knowledge. He points to the universities as a provider of knowledge in the form of research, and knowledge in the form of competent and skilled people. This distinction is important because it does not only see knowledge as a standalone package, but links knowledge to people and their skills. Close cooperation with universities and other research institutions is underlined as important. The company supports some academic research through their research centres, for instance through professorships and joint work on research topics. A researcher emphasizes that: "(…) Science as a driving force of business development and innovation is very strong in our company." This is a clear statement of the role of knowledge in relation to innovation. Knowledge is seen as permeating activities throughout the industry.

Knowledge as a driver of innovation calls for knowledge development on several levels and areas. Scientific knowledge and academic research is an obvious candidate for knowledge development, which may be seen as fuelling the development of new solutions and building competencies. For example, this was the case in the Snøhvit project, in which new solutions was developed partially due to research on multiphase-flows. In addition, there is a need for development of "knowledge on knowledge". This is a variety of organisational capabilities, for instance knowledge on how to communicate satisfactorily so that operative needs get through to research facilities, and vice versa that researchers communicate novel solutions and are given the opportunity to test these. This also calls for an improved understanding on all parts, of these needs, a sort of "knowing what's going on", to know what to work on. Lazonick notes that traditionally, Japanese firms have been integrating shop-floor workers in organizational learning, whereas companies in the US tended to maintain a sharp segmentation in the labour force. Cross-functional integration is seen as important in producing an integrated skill base (Lazonick 2005:42-45). A dimension of the emphasis on communication is also to develop competencies in how to handle internal tension, whether it be between departments, professional groups, operative units and administrative or R&D units and so forth. Knowledge on knowledge also interprets to a need for development of competencies in searching widely to find new knowledge and exploiting it. Knowledge in scientific and technological fields not traditionally applied by the oil and gas industry may prove itself useful. Further, knowledge in how to manage these relations satisfactory is crucial to be able to obtain the "right" information. Similarly, such knowledge is needed to be able to identify and manage ideas internally and externally. Organizational capabilities are here explained as critical for developing other kinds of knowledge and thus responding to the drivers of innovation. Managers must be able to identify competitive strengths and weaknesses within the firm's skill base, and make changes for enabling an innovative response to the drivers' (Lazonick 2005:34). Structural archetypes may thus be seen as structures which may or may not be supporting these organizational capabilities (Mintzberg 1979, Thompson 1967).

5.2 Industry-specific conditions

In the above, three categories of drivers of innovation have been introduced, as well as some suggestions to what kinds of needs for knowledge development that follows from these. As noted, drivers of innovation may be seen as a general analogy to task environment (Thompson 1967 in Jacobsen & Thorsvik 2004), and opportunity conditions (Malerba 2005, Pavitt 2005, Cohen & Levinthal 1990). Thompson argues that certain types of organisational structures correspond to the task environment. He introduces two continuums; degree of homogeneity or heterogeneity; and degree of stability or dynamic. The first corresponds to the degree of functional differentiation in an organization, and the latter influence whether decision making is centralized or not.

Companies operating in the oil and gas industry may be situated according to these characterizations. The environment in the industry is quite obviously heterogeneous. But is it stable or dynamic? As noted, the respondents argue that the pace of the industry is slow and conservative. Risk assessment and security issues are brought forward as a reason for this, together with the large investments needed for building out fields and keeping operations running. But, I do not agree that this is grounds for labelling the environment stable. The notion on risk assessments, security issues and heavy investments shows that there is an intrinsic understanding of these issues as bearers of large uncertainties. Further, Lazonick notes that:

> *(…) the innovation process is uncertain, because, by definition, what needs to be learned about transforming technologies and accessing markets can only be known through the process itself. By investing in learning, an innovative strategy confronts the uncertain character of the innovation process (Lazonick 2005:30).*

Notably, relations with industrial suppliers, developers, innovators and R&D communities might mean that some units within companies in the industry are exposed to highly dynamic conditions, as innovation processes are inherently uncertain (Pavitt 2005:88). This is not a stable environment; but is it dynamic in every sense? I would argue that different units within companies face different conditions, some of which are stable, and some of which are dynamic. This places a company's environment as heterogeneous on one dimension, and on the other dimension the environment is somewhat stretched from stable to dynamic, emphasizing the extent to which a department or project is faced with uncertainty. Companies in the oil and gas industry are faced with conditions which in some cases fit with a Schumpeter Mark II pattern, in which the technological regime is characterized by high appropriability and high cumulativeness of knowledge, whereas in other cases, such as the exploration of new and technologically challenging fields or the introduction of new environmental regulations, some conditions fit better in a Schumpeter Mark I pattern (Herstad in Nifustep Rep. 4/2008, Malerba 2005). This is due to the fact that for instance new challenging fields or new environmental regulations may call for a change of the technological regime. This presupposes an organizational form which enables a certain degree of autonomy and flexibility, somewhere along the continuum from the divisionalized form to the adhocracy. Lazonick argues that organizational integration is what determines the innovative capability in a firm, and that the type of organizational integration is contingent on industries, technologies, markets, institutional environments and over time (Lazonick 2005:50).

To solve the need for knowledge on scientific and technical issues, and at the same time secure a capacity for internal translation and application of this knowledge, integration of a R&D unit in the company may prove to have important advantages. This is largely due to the combination of specialized and tacit knowledge which may be achieved through intrafirm collaboration, resulting in firm-specific experience. The aforementioned cross-functional integration may serve as a possible strategy for this (Lazonick 2005:42-45). However, if the knowledge needed is reliant on several specialized bases of knowledge, it may be more beneficial for the company to collaborate on parts of, or the whole production of a service, process, or product with suppliers. This technological convergence might be beneficial because the supplier is specialized in combining certain knowledge bases and user feedback, an activity which may include skills of craft and often tacit elements. However, there might be great advantages in maintaining a close relationship with the supplier, in order to exchange information and knowledge related to development, operation and improvement of the specialized input (Pavitt 2005:89-93). Lazonick notes that: "(…) the essence of the innovative firm is the organizational integration of a skill base that can engage in collective and cumulative learning (Lazonick 2005:34). In-house R&D together with relations between firm and suppliers, customers and research communities may prove useful for creating or acquiring knowledge and experience on technological issues, relational competencies, communication, and strategies for information search.

6.0 StatoilHydro and Knowledge

The previous chapter has discussed the drivers of innovation under which StatoilHydro operates, and what kinds of needs for knowledge creation that follows of these. The following will consider how the company actually organizes its knowledge development and use under these conditions, in order to answer the second research question: “How is the firm organizing its knowledge development and use within these conditions?” The first section will account for the general organizational structure in StatoilHydro, which is senn as a reflection of the opportunity conditions (Malerba 2005, Pavitt 2005, Cohen & Levinthal 1990) in the industry. The second section will make use of a framework that considers two modes of innovation and learning which both play a role in the oil and gas industry; the Science, Technology and Innovation (STI) mode; and the Doing, Using and Interacting (DUI) mode (Jensen et al. 2007). Some organizational practices will be examined in order to assess the extent to which the two modes of innovation and learning exist within StatoilHydro. Further, some perspectives on organizational practices regarding cooperation and search will be discussed. These perspectives may suggest that the two-modes-framework might need an elaboration. The last section will have a look at a particular project within StatoilHydro, called the “New Ideas” project. It is intended to support the pursuit and development of ideas in the company. Relevant literature will be used to discuss the significance of this project for use and development of knowledge, as responses to the drivers of innovation. This is interesting also in relation to the Innovation Café. This is an arena where operative units may present issues and challenges to the research community in the company. The intention is for this to be an informal arena for discussion and brainstorming, no strings attached.

The following will consider how the company is organized under the conditions of the innovation drivers.

6.1 The organization of StatoilHydro

According to Thompson (1967), a company with a heterogeneous, but stable environment will seek to divide its environment into several internally homogenous subgroups. Special departments are established for each subgroup and are supposed to be self-supporting. This typology is to an extent visible in StatoilHydro, through the different business areas; Exploration and Production Norway, International Exploration and Production, Natural Gas, Manufacturing and Marketing, Projects, and Technology and New Energy. However, for some units and projects within these business areas, the characterization of the environment as heterogeneous and dynamic is more appropriate. For instance, large projects like Snøhvit and Ormen Lange belong under this typology, as well as some of the innovation projects in the research centres. They have in common that there is a high degree of uncertainty because they in one way or the other are breaking new ground. More specifically, they are situated in an environment where knowledge development may occur through disruptive or radical innovation, for instance through applying knowledge from a different technological domain to solve an industrial challenge. According to Thompson (1967), a heterogeneous and dynamic environment will often invest in vertical and horizontal systems for exchanging information. It is also typically characterized of decentralisation, less standardisation and a somewhat less clear division of labour; an "organic" structure (Thompson 1967 in Jacobsen & Thorsvik 2005). For instance, the research centres participate in projects configured as matrix-organisations with people assigned from different departments.

The categorization of StatoilHydro's environment points out that it exists in a heterogenous environment and on a continuum between stable and dynamic conditions. This positions the company as predominantly an organic structure. Within the heterogeneous dimension, two structural archetypes are particularly relevant to StatoilHydro; the divisionalized form and the adhocracy form. These commonly correspond to stable and unstable environments respectively. It is however important to stress that the structural archetypes are ideal types, and that no "pure" form is found in an organisation. Rather, organisations in real life are a mix of two or more types (Jacobsen & Thorsvik 2005:99-107, Lam 2005). This mix is also evident in that the innovation patterns in the company bears elements of Schumpeter Mark I *and* II. Innovative activity aimed at continual improvement of exploration and production tends to be characterized by high accumulation, high appropriability and correspondingly high barriers of entry; *creative accumulation* found in Schumpeter Mark II. However, StatoilHydro is also engaged in the development of new technological regimes of renewable energy, as well as exploring new and alternative technological solutions to challenges in the established business areas. Entrepreneurs and small and medium sized firms play an important role in these technological regimes, which to some extent is characterized by widespread externalities, and where *creative destruction* is at play, referred to as Schumpeter Mark I (Herstad in Nifustep Rep. 4/2008, Malerba 2005).The conditions under which StatoilHydro operate call for a relatively flexible organization which is fit to handle change and uncertainty as well as a continual development of the core knowledge bases. An organizational structure with a mix of divisionalized structures as well as adhocracy structures may be a response to this.

6.2 Development and Use of Knowledge

There is a variety of knowledge needed to respond to the drivers of innovation. This section will consider the empirical findings by the use of a framework describing two modes of learning and innovation (and thus practices to solve various needs for knowledge development). The two modes are the Science, Technology and Innovation (STI) mode, and the Doing, Using and Interacting (DUI) mode. Different themes relating to the two modes are discussed below.

6.2.1 DUI-mode learning and innovation

DUI-mode learning and innovation may be divided into a set of organizational practices. These are discussed together in this section. They are thoroughly described in literature on “learning organizations” and “High Performance Work Systems” (Clegg et al. 2005, Cohen & L 1990, Dertouzos 1989, Jacobsen & Thorsvik 2004, Jensen et al 2007, Lazonick 2005, Narula 2003, Pavitt 2005, Wenger 1998). The literature provides elaborate typologies of organizational practices (which are relevant to the flexibility and ability to learn and unlearn of the adhocracy form). These organizational practices are intended to facilitate employee involvement in problem-solving and decision making. (Jensen et al 2007).

The research organization (i.e. not only the two research centres, but the internal research community at large) within StatoilHydro is organized according to a matrix system. This system is made up of two axes, with one axis holding research resources such as scientists, and a project-axis defining goals and holding financial funding. These two axes operate together to form project-teams, in which members may come from different disciplines and departments. This is a form of organizing interdisciplinary workgroups which is established in order to facilitate problem-solving and learning in the innovative activities of the company. There are also several arenas for discussion and sharing experience, which may be called quality circles. One respondent notes that there are internal process-networks and professional networks across the organization where solutions and needs are discussed and passed on.

Often, there are discipline leaders (professionals holding special positions in technical or scientific knowledge) who facilitate the sharing of experience and skill to units who need it. There are also peer reviews, in which experts on technical or scientific fields, and specialists from operative units are assembled to assess an idea or an innovation project. Further, Innovation Café's provide a meeting point where operational needs are communicated to an interdisciplinary community of researchers, which come up with and review ideas in an informal setting. There exists a particular project for nurturing and commercializing ideas, called New Ideas. In this a committee of professionals evaluate ideas and distribute funding and personnel, based on similar criteria as the peer review. It is also worth noting that units are relatively autonomous, insofar they are free to structure their innovation-processes as they see fit.

The flexibility of these organizational structures is underlined as an enabling feature for learning and innovation. Learning should happen "where things happen", and those performing services and creating products are often better at seeing what needs to be done than the top management. This calls for a decentralisation of decision-making, sometimes through autonomous groups. These need to have the necessary skill and freedom to think creatively about experiences, and undergo processes of trial and error. Written rules and routines are often kept at a minimum, and the activites done under these conditions are often divided into roles, rather than "jobs" (because a "job" defines an area of responsibility, whereas different roles may have overlapping task-descriptions). Further, horizontal communication is of great importance (Jacobsen & Thorsvik 2005:342-342). Different parts of the company absorb different kinds of knowledge from its environment, and this knowledge need to be circulated and linked internally to identify its value to the organization (Cohen & Levinthal 1990). Adequate communication between the various parts of StatoilHydro is thus crucial. The process- and professional networks and the peer reviews described above, as well as the matrix-organisation, are apt to facilitate collaboration and the development of localized and tacit knowledge as the DUI-mode emphasizes. In such organizational practices, know-how and know who are crucial. Enabling learning through organizational practices which are stressed by the DUI-mode of learning and innovation are thus a critical factor to develop the needed knowledge to respond to the drivers of innovation.

A scientist remarks that stronger organizational abilities are a key area of continuous improvement. The reason for this is that even though StatoilHydro is a large company, relatively clear and short lines of communication is needed for sustaining flexibility and a hands on approach to solving issues. Too much bureaucracy is seen as a threat to sustainable activities. Several of the respondents suggest that rotation of people to various functions in the company, and particularly contact with the operative units, are of great importance to achieve a thorough understanding of the business. It is noted that some scientists have been walking around with tunnel vision, focusing only on own scientific work and showing little understanding for issues in the operative units. The difference between the US form and the Japanese J-form of organizational integration may be seen in relation to this statement (Lazonick 2005, Pavitt 2005). Further demarcations between employee groups are assumed to be softer in the J-form of organizational integration, which may facilitate more effective communication in the organizational layers (Dertouzos 1989:97)

The respondents express a need for reconciliation of the tension between desires to develop ideas and test pilots in the research centres, and the needs for handling current issues in operative units. Exploring alternatives for the integration of functions and softening demarcations between employee groups (for instance between researchers and platform-personnel, analogous to the Japanese shop-floor workers) may be one element in facilitating increased DUI-mode learning and innovation. This would also be a step towards Wenger's (1998) concept of communities of practice.

One theme of the DUI-mode of learning and innovation is concerned with cooperation with customers and suppliers (Jensen et al 2007). In this context, customers may be understood as other units in StatoilHydro to which the research community provide products and services. In this particular case-study, cooperation in the DUI mode is thus linked to organizational integration, softened demarcations and high performance work systems. As several of the respondents remark, there is a tension between operative units and researchers in developing solutions for different operative purposes, and testing ideas and performing pilot-projects. It is important to recognize that this is only part of the picture. Generally, problems at a field unit are communicated to a research centre, a researcher tells:

> *(…) operational problems in a field unit, it would be natural for them to make contact with a technological milieu, and such is often located at the research centres. And then this becomes the dialogue that contributes to a communication of some need in a field unit. (…) I believe this is one of the strongest driving forces of innovation. Exactly the point of understanding the needs of the clients. (…) It is communicated, partially formally, and partially through acquaintances.*

This is a very explicit expression of operational needs as a driver of innovation, and it also notes the importance of understanding the needs of the clients. This underlines a need for knowledge development, regarding satisfactory communication between research centres and operational units. It also points to how this happens, through formal communication and individual initiatives.

The networks and forums for exchanging needs and solutions are used actively. Sometimes a need is expressed by several of the operative units (customers), which mean that the need is amplified, and further cooperative action is taken to investigate and produce specific knowledge of the current issue. For instance, this includes special task forces of scientists and engineers sent out to platforms. These cooperate with platform personnel in order to achieve a better understanding of the issue, and propose solutions developed through this interaction. By nature, this interaction is characterized by highly localized and tacit knowledge, as well as elements of codified and globalized knowledge. Such interaction is thus fuelled by DUI-mode learning as well as STI-mode learning. This is what Asheim & Gertler has labelled synthetic knowledge, i. e. knowledge which requires know-how, practical skill and "(…) learning by doing, using and interacting" (Asheim & Gertler 2005:295).

Suppliers may be sources of tacit knowledge and skills which are highly specialized to technological regimes. Cooperation with suppliers may thus be beneficial for learning skills and expertise on the specialized development, operation and improvement of a product or service (Pavitt 2005:89-93). In the DUI-mode, cooperation with suppliers and customers relate to learning by interacting. The STI-mode will consider learning by interacting as cooperation with knowledge institutions, and such relations are thus not part of the DUI-mode of learning and innovation (Jensen et al 2007). A researcher points out the importance of technology agreements, which are agreements on technology development between the company and suppliers. There has been a long running cooperation particularly with firms working with oil wells and reservoirs. FMC Technologies, Schlumberger, Halliburton and Baker are among major participants in this. This cooperation contributes to increased understanding of challenges and possible solutions for wells. It is also important for reducing risk and providing confidence in working solutions. Some suppliers possess highly specialized knowledge on products and services, which may provide useful insights for the company. This knowledge contains elements of tacit and localized knowledge, as well as codified, science-like knowledge. Interacting with the supplier is thus an important activity in order to stay ahead, and achieve an understanding of why a product or service works, and how and where it may be applied (Pavitt 2005:89-93). A respondent has noted that:

> *(…) we saw that the value of maintaining the same supplier over time, knowing the people coming out who knew the platform, this advantage was that big that we have chosen to undertake a few such contracts. (…) there are four firms, dominating in the industry, with which we have cooperation on technology development. (…) had framework-agreements with specific suppliers in order to simplify the purchase, and improve our knowledge on that product and that supplier, so that we are certain, and may more easily see how we can make use of that product in construction-projects.*

The development of synthetic knowledge and learning by interacting is made explicit in this statement, and underlines the need for cooperation with suppliers. Such cooperation is part of what makes the company able to solve the needs for knowledge development and thus responding to the drivers of innovation.

6.2.2 STI-mode learning and innovation

It is stated by one of the respondents, that some 2.2 billion NOK is spent on R&D internally, and external R&D activities and linkages. In terms of internal competencies, there are continual evaluations as to what kind of disciplines that are not sufficiently represented, and where this should be situated. A researcher notes that rotating scientifically trained personnel back and forth between operative units and research facilities is seen as highly beneficial both for research and achieving an operative unit of high quality. However scientifically trained personnel has also posed a challenge in the past, before establishing the matrix system. In a combined resource and task organization, it was found to be difficult to recruit scientists to new projects, because they tended to give priority to their own tasks and interests. This was a kind of "king on the hill" problem, which posed a big dilemma for the research organisation in terms of getting the mix of disciplines right in projects.

Laursen & Salter (2004) note in an article that universities' direct contribution to industrial innovation is most likely among companies that have existing capabilities in R&D, and a relatively open approach to seeking information from external sources. However, it is noted that this describes a relatively linear relationship between universities and firms, which may be misleading. Companies like StatoilHydro, that use several sources of knowledge such as suppliers, customers, own R&D and fairs and conference, tend to also draw on knowledge stemming from university research; but this is just one of many sources. (Laursen & Salter 2004:1212). StatoilHydro is engaged in various types of cooperation with universities and research institutes. One researcher remarked that there is extensive cooperation with the Norwegian University of Science and Technology (NTNU), in Trondheim. One of the research centres of StatoilHydro is located in Trondheim and is host to academic work and some professoriates stemming from NTNU. The company also has cooperation with The Norwegian Academy of Science and Letters (DNVA), through a program called VISTA. It is noted that this cooperation is "(…) simply because we want to stimulate academic research within our disciplines. This is obviously important to us."

It is also worth noting that StatoilHydro participate in work where students are challenged to find solutions to current issues in the industry, and the company is host to student-projects as well as visiting scientists and researchers from universities and research institutes. Interaction with universities and research institutes is dominated by codified and globalized elements of knowledge, though carrying some tacit and localized elements as well. Asheim & Gertler has labelled this analytic knowledge, highlighting the extent to which this knowledge is characterized by know-what and know-why types of knowledge which is found in the STI-mode of learning and innovation. Knowledge creation is here typically based on "(…) formal models, codified science and rational processes" (Asheim & Gertler 2005:296). One of the respondents has noted that access to university knowledge through the basic competencies of graduates and through the work of research communities is a major task for the government, if it wants the domestic industry to be internationally competitive.

6.2.3 Summary of the analysis of DUI and STI modes of learning and innovation

The above analysis of the use and development of knowledge in StatoilHydro has applied the DUI-mode and STI mode of learning and innovation. This has been supplemented by a distinction between synthetic and analytic knowledge. In the analysis of the DUI-theme on cooperation with customers and suppliers, it is argued that a task force interacting with platform personnel to solve an operative challenge will participate in the production of tacit and highly localized knowledge, i.e. synthetic knowledge, but will also make use of elements of codified and globalized knowledge, related to the technology at issue. A reverse mechanism may be identified in the production of analytic knowledge. Though analytic knowledge is characterized by codifiable and global knowledge, mainly emphasizing know-what and know-why knowledge, this type of learning and knowledge production is also characterized by tacit and localized elements of knowledge. For instance, cooperation with universities through (as stated by Jensen et al 2007) often informal and personal relationships may require know-who knowledge, which is predominantly found in the DUI-mode of learning and innovation. Elements of know-how knowledge may also be traced in the way in which this interaction go about, for instance through joint research on specific scientific issues, in which failed experiments or projects produce knowledge which is never published or made formal (Asheim & Gertler 2005). As such, the DUI-mode and the STI-mode of learning and innovation may be seen as mutually supporting and interdependent in StatoilHydro's case. Learning through interacting may to an extent be found in both modes of learning and innovation, not only in the DUI-mode.

I would like to point out that the descriptions of DUI mode and STI mode cooperation show some characteristics of communities of practice (Wenger 1998), in the sense that it involves close cooperation, with relatively informal relations and consists of people with more or less shared experience and to a various extent common expertise in a given field. This shows that the organizational practices not only are confined to organizational boundaries, but extend beyond these to inter-organizational relations between individuals or groups of individuals. These practices contribute greatly to the innovative performance of StatoilHydro. This contribution is most significantly the way in which such practices build and improve upon various types of knowledge and expertise, which may serve to further improve innovation.

6.3 Cooperation and search

Cooperation can be used as a substitute or supplement to in-house R&D. There is a variety of forms such an arrangement may take, but a common feature is a commitment to the sharing of existing knowledge for the purpose of developing new knowledge. A company's boundaries may be porous in two ways; inside-out and outside-in. Cooperation may provide opportunities to access complementary resources, and to internalize external knowledge spillovers (Vision Eranet Report 2008). Moreover, cooperation may be an option in cases where a company is participating in globalized markets, but due to the capital-intensity of such activities and the inherent risk of innovation, a firm cannot afford to be present in every country. A company may wish to exploit the characteristics of given countries (or technologies) that represent inputs to innovative processes, which is required to generate new competitive advantage. Internalizing and undertaking all aspects of value-adding activity through exclusive units in every location is Utopian, and perhaps not desirable (Narula 2003). StatoilHydro is for instance engaged in exploration and production in Canada and Azerbaijan, as well as several other countries. These undertakings are not all exclusively StatoilHydro activities, but to a varying degree cooperation with other actors. Choosing to cooperate requires trust, insofar the companies involved attempt to develop mutual understandings of what is to be achieved and expose their knowledge. Cooperation may be subject to lock-in, due to the intense engagement and irreversible investments made. (Vision Eranet 2008:15, 32, 62)

Search on the other hand is essential for businesses to gain an overview of what goes on in the industry beyond their cooperative partners, and is thus usually broad. (Vision Eranet 2008) Search as an organizational practice is to a varying degree infused in the aforementioned indicators of DUI and STI modes of learning and innovation. A company interface with external actors and exchange information and knowledge to a varying degree with these actors (Ahuja & Katila 2002, Laursen & Salter 2006) Notably, this means that the boundaries between the firm and its environment becomes more porous and "(…) embedded in loosely coupled networks of different actors, collectively and individually working toward commercializing new knowledge" (Laursen & Salter 2006:132).

Breadth in relation to search practices refers to how many sources or search channels that a firm uses in its innovation, in other words how broadly a company explore its environment, and surrounding environments. Depth refers to the intensity of such relations, i.e. whether the firm draws deeply from a given channel, and thus exploits that channel. It is argued that a firm will go through a process of trial and error with a given search channel, in order to learn how to absorb knowledge from this source (Ahuja & Katila 2002, Laursen & Salter 2006). An example for StatoilHydro would be engaging in cooperation with a new university, a new supplier, or even setting up a new operational unit in which the terms for cooperation with the research community and other supportive structures must be negotiated.

StatoilHydro is broadly engaged in search through their extensive cooperation with a large number of actors. The *search space* of StatoilHydro, i.e. the range of actors with which the company interact, may be divided in three categories; (1) the *internal* search space is constituted by the company's research community, units within the various business areas of the company (such as platforms, terminals, different development programs etc), and top management; (2) the industrial search space is made up of competitors, suppliers, discipline-specific research-communities and universities, and organs for industry-specific regulations and production of knowledge (for instance the Ministry of Petroleum and Energy, the Petroleum Safety Authority Norway, the Directorate for Civil Protection and Emergency Planning etc); (3), lastly, the outside-industry search space constitutes actors producing knowledge which may be useful for StatoilHydro, but which has not yet been applied by the oil and gas industry. (Katila 2002)

The degree of maturity of knowledge drawn from the different actors affects the innovation in different ways. For instance, the internal knowledge base of a firm is assumed to have a curvi-linear (inverted U-shape) relationship to innovation. More specifically, this means that the innovation in StatoilHydro is positively affected by a balanced mixture of mature (old) and new knowledge. The tension between the research centres and the operative units may give an illustration of this. Further, relying on old knowledge stemming from the industrial search space will most likely harm innovation in the company. Thirdly, knowledge from the outside-industry search space is assumed to have a positive effect on innovation.

The last point is elaborated by a respondent, as he notes explicitly that knowledge produced for an entirely different domain has proved useful. Knowledge from medical technology – computer tomography which is used for visualisation of internal organs – has been adjusted to analyze geological core samples. Another example is prevention of hydrate formation in multi-phase pipelines. These hydrate formations take the form of an ice-structure, and may plug the pipeline. Some sort of antifreeze liquid is needed, and one researcher got the idea of looking to animals or insects living in arctic areas. Some small creatures were identified, which produced frost-reducing substances in their bodies. The researcher then tried to copy these chemical substances and analyze how much would be needed for a pipeline. This is put forward by the respondent as an example of how important it is to open up for knowledge and inspiration from elsewhere, and how this drives innovation. The examples from medical technology and biology illustrate that old knowledge from the outside-industry search space may enhance innovation. (Katila 2002)

An interesting hypothesis in the search-perspective is that some firms tend to "over-search", meaning that at a given point, efforts towards search exceeds the payback in form of applicable ideas and knowledge. A major reason for this is that interaction with a source needs to be sustained over time, because search not only involves scanning wide numbers of sources, but also to learn and draw knowledge from these sources (Laursen & Salter 2006:135-136). As noted above on the DUI and STI-modes of learning and innovation, interaction and sustained relations is important for learning and knowledge development. It is a challenge to know when and where to locate efforts in order to be able to absorb knowledge from a source, and reducing the uncertainty as to whether that source will be useful for innovative activities; "(…) a prepared mind" is needed (Jensen et al 2007:681). A respondent notes that the role of the researcher is changing:

> (…) *I think that it changes the role of the researcher; I think that to connect to those who may contribute with their own work, and actually start there… That is a somewhat different role than what has been seen before, and it might go a little further than the academic view of things, but from an industrial standing point, this is important. Procter & Gamble has made a brand new way of doing innovation, which they call* Connect & Develop*, which I believe is good. It may give the company more, with fewer resources, compared to other strategies.*

This comment highlights the importance of search as a strategy for developing knowledge and learning through interaction. The Procter & Gamble (P&G) strategy is a stark contrast to traditional research and innovation, and is an example of a type of "reverse" search strategy, where innovators and people with ideas make contact with P&G and negotiate development contracts with the company. In addition, the company license trademarks, technologies, engineering solutions, market research methods etc (www.pg.com). The respondent's note on how the role of the researcher is changing may be seen as an illustration of how absorbing knowledge and learning from different sources, and where to locate this, is contingent upon a "prepared mind", a point which has been emphasized by several scholars (Asheim & Gertler 2005, Cohen & Levinthal 1990, Jensen et al. 2007, Laursen & Salter 2004/2006). Further, an awareness of how organizational integration affects internal communication and abilities to explore and exploit knowledge is important;

> *"(…) Organizational integration is necessary for firms to absorb knowledge from the external environment, as this requires broad interfaces with this environment, and for these to be able to recombine, redevelop and exploit this knowledge through internal communication and diffusion. For instance, it is reasonable to assume that the marketing department has its ears more open towards customer preferences than the R&D department; but what is absorbed has little value if it does not reach and is*

understood by R&D. Similarly, the purchasing department is in a much better position to search the supplier base for ideas and knowledge, but the value of this may very well be contingent on diffusion to and understanding by R&D, marketing and top management." (Vision Eranet 2008:16).

The next section will give a brief account of two empirical findings in StatoilHydro, which describe how innovation projects may come about, and how their initial journey may begin.

6.4 The New Ideas Project and the Innovation Café

StatoilHydro has established a project called "New Ideas", which is a mechanism for developing ideas which does not fit in with the thoughts and strategies of the established development programs. The project owns its own pool of financial resources which is separate to the financing systems of the ordinary R&D programs. The purpose of New Ideas is that potentially great ideas which do not fit with company strategies should be given a chance to be developed and tested. In line with company philosophy, an idea does not have to be fully developed, or even thoroughly investigated before being registered internally. Ideas often stem from researcher interaction with operative units, or the operative units report problems themselves. Innovation Cafés are also sources of ideas (which will be accounted for below), as well as interaction with suppliers, universities, research institutes, and participation at fairs. It is noted that knowledge of available solutions and building blocks, and the individual knowledge and expertise of the innovator is a prerequisite for understanding the challenge. Interdisciplinary collaboration is brought forward as a salient feature of this understanding.

When an idea has been registered, the innovator may apply for funding. The idea is then brought to a peer review, which assess the idea and its potential to solve a given need. This peer review consists of experts from various fields, which give an evaluation of the idea and its technological aspects. The main focus is here whether the idea is technically doable, not whether it has business potential. A group of leaders will then assess needs for personnel and financing, and New Ideas is thus considered as a possible funder. As it is implicit in the New Ideas project that the innovations not necessarily have to be part of current R&D projects, this allows for the exploration of alternative strategies for developing the company.

6.4.1 "This is not what we do, is it?"

One innovation came from a group of researchers initially brought in to assess solutions to a problem with gas flowing into a pipeline designed to extract oil. The researchers were supposed to assess different solutions provides by suppliers, and pick the best solution for implementation. However, none of the solutions were found to be good enough. The researchers speculated on alternative ideas, and came up with a solution based on prior experience with the effects of flow-pressure on gas and oil. The idea was registered, and a peer review was undertaken. It was however not met with enthusiasm amongst the researchers in the peer review, or by the research management. A general attitude was that this was not part of "what we do", and that it was not important. The innovators persisted in their attempt to develop the idea, and were ultimately granted funding for making more models and simulations, and eventually lab-tests. The idea had to compete against the suppliers' concepts, but in the end persuaded in providing the best solution for the problem, and is now implemented on a platform. It is estimated to provide massive profits for the company, and is named "a possible game-changer".

This example gives an illustration of how an idea which stem from interaction with suppliers, and initially is assumed to be far off the traditional track of the research centre, may provide substantial advantage if it is allowed to be developed. The researchers, who initially were supposed to assess solutions from suppliers, had to rely on synthetic as well as analytic knowledge when they came to the conclusion that none of the initial solutions were satisfactory. This knowledge also played a crucial role in enabling the researchers to come up with a new idea. Further, it may be argued that the resistance the researchers faced internally was due to an internal, though local, lack of absorptive capacity; in a sense, the peer review board, and the research management did not have a sufficiently "prepared mind" which made them able to identify the idea as a good one (Cohen & Levinthal 1990, Jensen et al. 2007). It is not uncommon for large companies to struggle with this type of challenges, as managers seldom are able to fully understand their environment, and thus opportunities for innovation which may yield great competitive advantage (Christensen 1997) The funding system did however allow for the idea to be developed further, and this revealed great potentials.

6.4.2 Innovation Café

Another mechanism for solving the needs for knowledge development is the Innovation Café. This a meeting place for operative units and researchers which is set up a few times during the year. The general framework is quite simple: the duration is approximately one hour, people from the research organisation are gathered on a voluntary basis, and presented with a need in a operative unit, and some failed solutions to the problem. They are then divided into teams of four or five, and given a certain amount of time to brainstorm about the problem. After 20 minutes, the groups give a brief summary of their ideas and discuss together. Then the groups separate and discuss for another 20 minutes, before summarizing and discussing again. The representative from the operative unit is present and answers questions and comment on the different ideas. After the Café, the ideas are being sent to the representative, which may get in contact with the people who have proposed the different ideas and establish further cooperation. This is a type of organizational practice which may contribute to DUI-mode learning, and it also gives opportunities for interdisciplinary cooperation and discussion. It is also a practice which may develop more communication and cooperation with operative units and contribute to the development of communities of practice, by offering an informal and voluntary meeting place for people working with related fields of knowledge. Further, such a practice may be viewed as a type of internal search strategy, in which knowledgeable people from various parts of the organization may provide linkages to external sources of knowledge and learning, from which they have prior experience (Katila 2002).

The analysis has provided a thorough examination of the key findings in this study and a basis for some summarizing thoughts on the significance for future firm strategy, policy making and further research. These will be elaborated in the final chapter.

7.0 Towards some Conclusions…

The analysis has provided insights that has sought to answer the two research questions; (1) What drivers of innovation is StatoilHydro operating under, and what kind of needs for knowledge development follows of these?, and; (2) How is the firm organizing its knowledge development under these conditions?

In the first part of the analysis, the drivers of innovation were identified in three categories (1) Operative Needs, (2) Standards, Regulations and Social Demands, and (3) Knowledge. This initiated an account on what needs for knowledge development such drivers bring about. Further, I have offered a discussion as to how these drivers of innovation generally are assumed to influence the way a company is organized, thus being able to solve these needs for knowledge development. In doing so, StatoilHydro has been situated in an organizational typology which bears elements of two structural archetypes; the divisionalized form and the adhocracy form.

The second part of the analysis has thus been concentrated on analysing how StatoilHydro actually organize their knowledge development and use. The DUI and STI-modes of learning and innovation has been seen in relation to empirical findings on organizational practices which are relevant for solving the needs for knowledge development. I further analyzed search as a practice for gaining knowledge, with special emphasis on StatoilHydros search spaces, and how the maturity of knowledge might influence innovation.

One of the major findings is that the organizational practices in StatoilHydro for developing and using knowledge bear strong elements of DUI and STI-mode learning and innovation. The two modes of learning and innovation may be seen as mutually supporting and interdependent in StatoilHydro, and strongly contribute to solve the needs for knowledge development and accordingly respond to the drivers of innovation. Further, search has been established as an organizational practice in the company which is regarded as important for enhancing innovation. Another interesting finding is the tension between the R&D organization and the operative units. The drivers of innovation represent different forces which may be conflicting; scientists may be driven by an urge to explore an idea which builds heavily on accumulated knowledge, whereas the operative unit needs to find solutions to specific challenges. This tension may however be beneficial to innovative performance, as it represents a mixture of mature and new knowledge, which by Katila (2002) has been suggested to enhance innovation.

7.1 Implications for Firm, Policy and Research?

The analysis suggests implications for the company, policy, and further research, which is elaborated below.

7.1.1 Strategies for StatoilHydro

As the above findings indicate, practices that come out of the DUI and STI modes of learning and innovation are positively related to StatoilHydro's ability to innovate. This suggests that the company might benefit from sustaining and developing these practices. Such development may for instance to a greater extent include non-R&D personnel in projects and different workgroups, or the other way around; facilitate the participation and rotation of R&D personnel in operative units. This would also serve as a possible strategy for searching StatoilHydro's internal search space. Organizational integration is important to be able to communicate across intra-firm boundaries, and identify value. The tension between R&D and operative units may to some extent be reconciled through this, but it is suggested to maintain some of the tension, due to effects of mixing old and new knowledge, which is seen as enhancing innovation (Katila 2002).

7.1.2 Implications for policy

As mentioned above, one major finding is that the company relies heavily on both DUI and STI-mode knowledge and innovation. However, policies on innovation tend to focus predominantly on linear models of R&D and correspondingly give primacy to traditional R&D, i.e. the STI-mode of learning and innovation. This needs to be complemented by mechanisms to support organizational learning and user-driven innovation. The educational system emphasizes first and foremost codified and globalized knowledge, but has the potential of improved training of students in practices found mainly in the DUI-mode of learning and innovation. Problem-based learning, workgroups and assignments which encourage interdisciplinary work may be examples of this. (Jensen et al 2007:690) Companies play an important part in the economy, as they synthesize knowledge and ideas from different sources and build specialized knowledge bases. This has positive extended effects on their surroundings. Should innovation policy mainly be occupied with the accommodation of education and research, and connecting companies through networks, or should it also make efforts towards building specialized knowledge by combining DUI and STI-modes of learning and innovation? The broad range of activities StatoilHydro engage in to develop their specialized knowledge bases, and their long term commitment to build knowledge in interaction with research institutions have positive effects on scientific knowledge bases. Scientific knowledge needs to be combined with the types of expertise and skill companies like StatoilHydro develop in order to create value. Building expertise and skill in private businesses is therefore important for commercialisation-purposes. Should this mutual interdependence be dealt with by innovation policy? An aspect of this might be how rules and regulations may provide market opportunities for such commercialisation.

Further, institutions prescribing public policy which is relevant to innovation, such as ministries of education, science, industry and economic affairs may need to be delegated responsibility for balancing the two modes of learning and innovation. (Jensen et al 2007:690) Markets are influenced by regulations and standards, and these components, together with knowledge-development, should be seen as interdependent elements in a holistic policy of innovation. This means that the different institutions need to coordinate their efforts towards policy supporting innovation. The industrial sector StatoilHydro is part of engage in capital intensive products which require large-scale infrastructure, long time-horizons for making profit, and consequently large losses if the efforts fail. This point to what part the authorities might play in order to create incentives for innovation. The Mongstad test-centre has been put forward as an example of this.

The White Paper on Innovation 2008-2009 demonstrate some efforts towards greater emphasis on DUI learning in the education system, first and foremost through reinforcing collaboration between education and working life, and on-the-job training. In addition emphasis is put on developing the industrial doctorates system, which may provide beneficial DUI and STI learning for both candidates and industry. The interdependence between industry-specific expertise and research centres producing scientific knowledge, with the purposes of commercialising research results is somewhat addressed, but the practical meaning of this intent remains unclear. The same is valid for how Norwegian Innovation policy will actually deal with issues of responsibility between the different Ministries engaged in innovation policy. For instance, will reinforcement of on-the-job training be the sole responsibility of the Ministry of Education and Research, the Ministry of Trade and Industry, or should this be a joint effort between the two? And if so, how should this responsibility be divided? The White Paper on Innovation 2008-2009 provides several promising motives, but it remains to be seen how this will actually be carried out.

7.1.3 Further research

The STI and DUI-modes of learning and innovation provide a basic framework for analyzing organizational practices in a large company in the oil and gas sector. The framework has however demonstrated some shortcomings, specifically in terms of demonstrating extent and quality of such organizational practices. Search breadth and search depth has been presented as a complementary to the framework, as well as maturity of knowledge. However, combining all these dimensions are perhaps more fitting for case-specific research focusing on qualitative data, rather than large scale quantitative data-surveys. Future research on DUI and STI learning might for instance consider a possible combination of these dimensions. Working out a framework which takes into account dimensions of search and cooperation together with the other STI and DUI mode practices may be used qualitatively for comparative analyses of case-studies, or even for large scale quantitative surveys. It is also worth noting that the propositions put forward by Katila (2002) on maturity of knowledge are based on longitudinal data from the robotics industry, and that a similar study of the oil and gas industry may be useful to strengthen the validity of the propositions for the latter industry.

Another issue for further research might be the development of a conceptual framework which considers environment/opportunity conditions in a broader sense. The concept of drivers of innovation adds standards, regulations and social demands as category which is influencing innovation through learning and knowledge development. The relations between opportunity conditions and regulations in the oil and gas industry need further research to unveil these mechanisms.

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Appendix I: Interview Guide for in-depth interviews

(based on themes and questions found in the project Managing Innovation in the New Economy, MINE)

Interviewees are asked to offer their opinions on questions, themes and assertions put forward by the interviewer. Based on information coming up during the interview, some of the points may be skipped.

BAKGRUNNEN FOR INNOVASJON I **SEKTOREN**

a) *Type kunder og deres behov, herunder:*

- hvorvidt de yter signifikant ekspertise om hvordan produktene som leveres fungerer
- hvorvidt behovene for kunder i våre sektor er svært komplekse (og sammensatte)

b) *Type og omfang av vitenskapelig og teknisk kunnskapsproduksjon, dvs. hvorvidt:*

- Egen sektor bidrar til akademisk forskning
- Ny kunnskap er som regel et resultat av intens interaksjon mellom bedrifter
- Ny teknologi bygger på den seneste teknologien fra andre bedrifter i sektoren
- Alle firmaene i vår sektor avhenger av den samme stabile teknologiske basis

c) *Faktorer som påvirker innovasjon i din sektor:*

- Kommersialisering av nye produkter forutsetter godkjenning fra regulerende myndighet
- Produkter må sammenkobles med andre produkter eller systemer for å ha verdi for kundene
- Forbedring av produksjonsprosesser gir mye høyere gevinst enn produktinnovasjon

d) *Ressurstilgang og vekst i sektoren:*

- Myndighetene tildeler store ressurser for å støtte forskning og innovasjon
- Innovative gründere har lett tilgang til finansiering (såkorn-penger, risikovillig kapital)

e) *Strategisk og konkurransemessig dynamikk i sektoren*

- Endringstakten i sektoren er svært rask sammenlignet med andre sektorer
- Eksterne faktorer tvinger frem uforutsigbare forandringer i sektoren

BEDRIFTENS INNOVASJONSSTRATEGI

1. ***Kilder for konkurransedyktighet og overtak, viktighet siste fem år og kommende fem år:***

- Overlegen teknologi og ekspertise (know-how)
- Sterkere organisatoriske evner
- Bedre rykte hos kunder
- Fordelaktige lover og reguleringer
- Portefølje med verdifulle patenter og opphavsrettigheter
- Større produksjons- og operasjonssystem
- Bredere multinasjonalt omfang på firmaet

2. ***Strategiske tiltak de siste fem år:***

a) *Viktighet av konkurransemessige tiltak:*

- Være aggressiv på anskaffelse av nye foretak i vekstområder
- Drive lobbyvirksomhet overfor myndigheter og påvirke opinionen for å få gjennomslag for egne syn
- Være aggressiv i beskyttelsen av eget åndsverk (defensiv patentering, søksmål, etc.)
- Leie de beste tilgjengelige forskere eller ekspert på markedet

b) *Viktighet av samarbeidstiltak:*

- Utvikle teknologiske veikart i samarbeid med andre firmaer for å redusere usikkerhet
- Inngå kompaniskap med myndigheter og konkurrenter for å utvikle ny basisteknologi
- Bygge strategiske allianser for å utvikle produkter og standarder
- Hjelpe leverandører og oppstrømspartnere til å forbedre sine produkter, logistikk og service
- Samarbeide med andre selskaper i arbeidsgrupper som utvikler standarder og normer
- Hjelpe utviklingen av reguleringer og sertifiserings organer til å legitimere produkter

3. ***Hyppighet i vurdering av antakelser som danner basis for strategi:***

- Hvem kundene er og hva de vil ha
- Hva som er kjernemarkeder og inntektskilder (revenue streams)
- Hva som er den beste blandingen av evner og kompetanse

4. ***Strategisk handling***

a) *Det vesentligste ved det strategiske initiativet som foretas nå*

- Bygge en radikalt annerledes kilde for konkurransefortrinn
- Styrke nåværende kilder for konkurransefortrinn

c) *Selskapets langsiktige strategiske perspektiv*

- Det forsøkes å forutse mange steg fremover for å unngå å bli låst i en dårlig posisjon
- Det utvikles flere parallelle strategiske veier og langsiktige alternativer proaktivt

4. *Hvilken andel (hvor mange) av dem som jobber med innovasjon bruker følgende regler som en veileder for sine handlinger:*

- Formulere egen spesialisert kunnskap på måter som er forståelig for andre spesialiteter
- Forstå temaer/problemer og betingelser innen andre funksjoner
- Håndtere problemer som oppstår i innovasjonsprosjekter ved å utforske et mangfold av alternativer

5. *Formelle prosesser i selskapet for å ivareta:*

- læring fra tidligere prosjekter og overføring av lærdom til nye prosjekter
- at ulike funksjoner lærer fra hverandre
- vurdering og forbedring av kapasiteter in teknologi, ny produktutvikling, markedsføring etc.

6. *Påstander om innovasjon i firmaet:*

b) *Identifisering og utvikling av kapasiteter for innovasjon: vitenskapelig, ingeniørskap, markedsføring, produksjon/fremstillings ekspertise, innovasjonsprosesser, informasjonssystemer:*

- Nye kapasiteter kommer frem før vi vet hvordan de kan anvendes til produkter
- Folk som bygger vitenskapelige og ingeniørmessige kapasiteter velger hva som skal utvikles, innen strategiske retningslinjer

c) *Ledelse av forretningsenheter for innovasjon: innarbeide nye produkter mot forretningsmodeller, gi nytt liv til forretningene via innovasjon, oppsyn med porteføljer og prioriteringer:*

- produkter
- BU ledere holder FoU informert om nye funksjonaliteter som behøves i produkter
- BU ledere har frihet til å avgjøre hvordan innovasjonsstrategien skal gjennomføres

d) *Ledelse av nye produktutviklingsprosjekter(NPD):*

- NPD team bestemmer selv hvordan produktkonseptet skal defineres, innen strategiske retningslinjer
- Det samme teamet kontrollerer hele NPD prosessen, fra definisjon til kommersialisering

SELSKAPETS INNOVASJONSNETTVERK

1. ***Selskapets posisjonering i verdiskapingsnettverk; et selskap forsøker å posisjonere seg selv i et nettverk av verdiskapingsaktiviteter i en sektor ved å definere sin egen verdiskapingsrolle i relasjon til andre organisasjoner i nettverket:***
   Vurder påstandene:

- Informasjon og databaser stilles til rådighet for selskaper engasjert i innovativ aktivitet
- Spesialiserte tjenester og rådgivning gjøres tilgjengelig for firmaer engasjert i innovativ aktivitet
- Selskapet er en system-integrator – subsystemer som er produsert av andre brukes til å skape produkter
- Komplekse systemer tilpasses for å fungere i bruksområdene til spesifikke kunder

FREMGANGSMÅTER SOM BRUKES FOR Å HÅNDTERE INNOVASJON

1. ***Fremgangsmåter for søk: hvordan uforske nye muligheter for innovasjon og lete etter nye ideer:***

- Opprettholde langsiktige interne programmer for oppdagelse av nye teknologier
- Avhengighet av interne kapasiteter for å oppdage markedstrender
- Flytting av personale fra enhet til enhet for å oppnå berikelse av ideer fra flere steder
- Ansatte får tid og ressurser til å utvikle nye ideer
- Vi samhandler med nøkkelleverandører og kunder for å få kunnskap om utviklingen på feltet
- Selskapet deltar i industri-nettverk (foreninger, konferanser, standardiserings-komiteer etc.)
- Selskapet samhandler med mange universitet spin-offs for å identifisere radikalt nye ideer

2. ***Håndtering av innovasjons-porteføljen:***

- Selskapet har en strukturert tilnærming med seleksjonskomiteer på ulike nivåer
- Mange uoffisielle prosjekter støttes for å utfordre den nåværende strategien
- Mellomledere har frihet til å omfordele økonomiske midler innen en totalpakke for innovasjon

3. ***Innovasjonsprosjekter som nylig er avsluttet:***

- Innovasjonene er kombinasjoner av ideer fra tidligere prosjekter
- Vi drar ofte nytte av kunnskap som i utgangspunktet ble produsert for et annet anvendelsesområde
- Det er omfattende gjenbruk av plattformer og moduler selskapet har utviklet før
- Representanter fra nøkkelkunder blir svært tidlig integrert i utviklingsgruppen
- Vi forsøker å dra stor fordel av leverandørers erfaringer i innovasjonsprosjektene
- Flere konsepter utvikles og testes parallelt før et produktkonsept velges
- Vi går igjennom mange skrittvise tilnærminger som fullstendig redefinerer konseptet og arkitekturen

- Så tidlig som mulig blir nøkkelkunder bedt om å teste prototypen og gi tilbakemeldinger

4. Kommersialiseringspraksis: kommersialisering som tar sikte på å fange verdier fra innovasjon

- Et strategisk rammeverk anvendes for å avgjøre de beste tilnærmingene til kommersialisering
- FoU må finne de beste måtene å kommersialisere innovasjoner internt eller eksternt
- Vi har en ny innsatsgruppe (venture group) som spesialiserer seg på utvikling av nye interne forretningsemheter
- Vi har en policy på å oppmuntre til spinouts ledet av eget personell

Appendix II: Interview Guide for informal interviews with innovators

1. Hvordan oppsto ideen?

Var det et uttalt behov fra driftsmiljøet?

Hvordan var første reaksjon på ideen, og kommunikasjonen rundt dette *før* peer review?

Hvordan ble et første søk etter relevant informasjon, kunnskap, forskning gjort?

Hva med ideer fra messer, nettverk, konferanser?

Technology Watch?

Ble Goldfire brukt? Hvordan?

Var det kontakt med forskningsinstitutter, universiteter?

2. Hvordan foregikk peer review?

Type eksperter?

Hva ble sagt der om veien videre?

3. Hvordan foregikk samarbeid med driftsenheter?

-pilotering?

-utveksling av erfaringer fra drift?

4. Var det samarbeid med leverandører?

På hvilket punkt i utviklingen?

-Hvordan foregikk dette?

5. Implementering?

- Hvor, hvordan, vurdering av suksess i etterkant?

Div:

Kommunikasjon på tvers av disipliner? Evne til formulering av problemstillinger?

Vurdering av alternative løsninger for problemet?

Styrker/svakheter ved måten prosessen foregikk, fra idé til implementering? Ift. søk, selve prosessen, kommunikasjon, ledelsesstrategier etc.

Appendix III: Guide for observation of Innovation Café

1. **Hvem er deltakerne?**
- Faglig bakgrunn
- Antall
- Hvor i StatoilHydro hører de til

2. **Hvem prater med hvem?**
- Hvordan blandes deltakerne ift. bakgrunn
- Hvilke retningslinjer følger man for dette

3. **Hva slags utfordringer/løsninger snakkes det om?**
- Ideer fra F-miljø
- Utfordringer fra driftsmiljø
- Har F-miljø utfordringer driftsmiljø kan bidra til å løse?
- Har driftsmiljø ideer F-miljø kan utvikle videre?

4. **Hvordan organiseres treffet?**
- Strukturering av ulike undertemaer/ideer/utfordringer?
- Ulike faser? Dvs. når man kan diskutere, når man kan presentere, når man kommer med feedback til de ulike temaer/ideer
- Hvem snakker mest? Om hva?
- Snakker man samme ”språk”?
- DUI vs. STI?

5. **Hva skjer etterpå?**
- Hvem følger opp resultatene av treffet
- Hvordan skjer dette
- Hvordan kommuniseres resultatene til ulike miljøer innen StatoilHydro